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SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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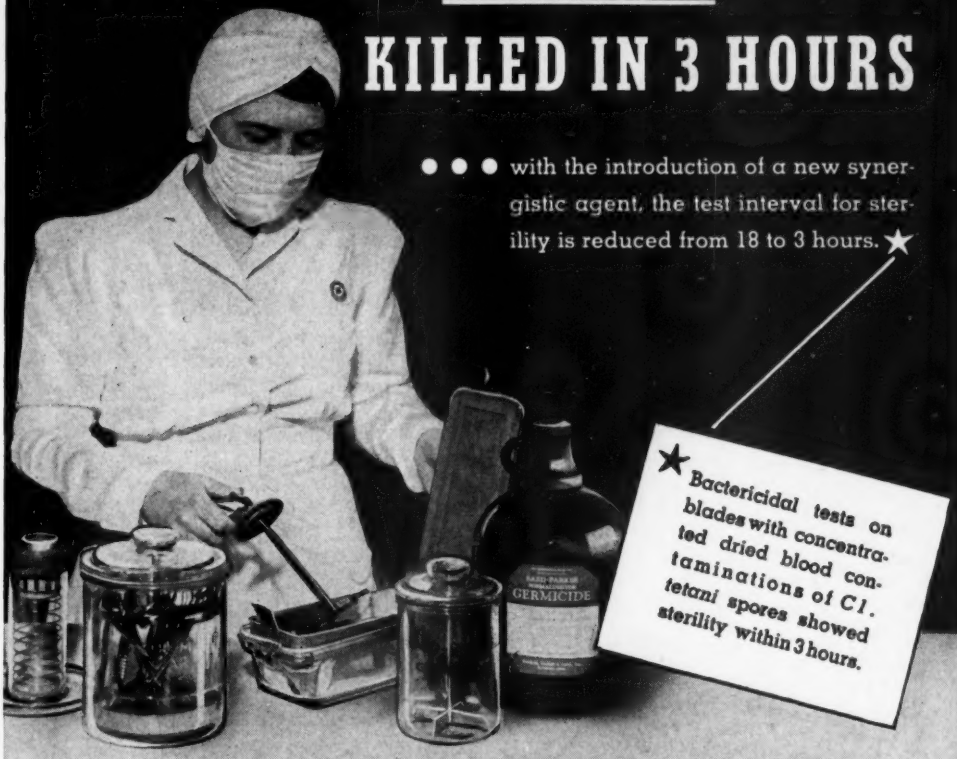

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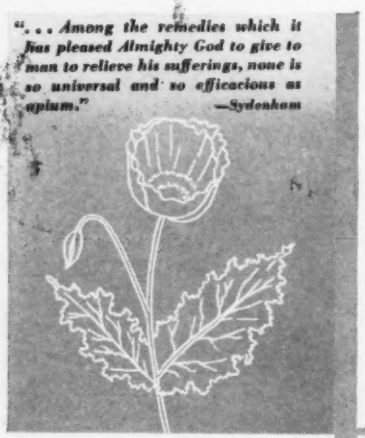
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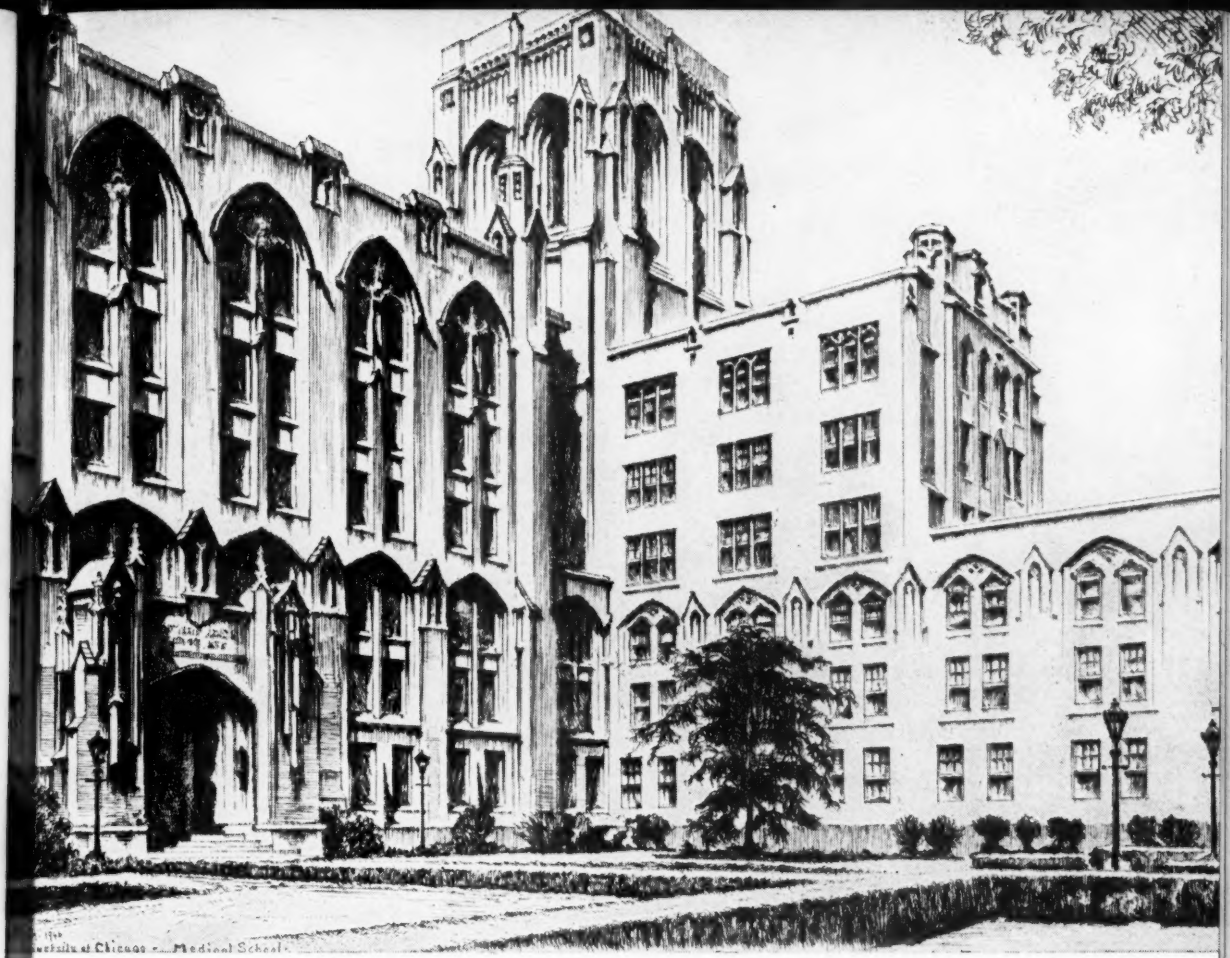

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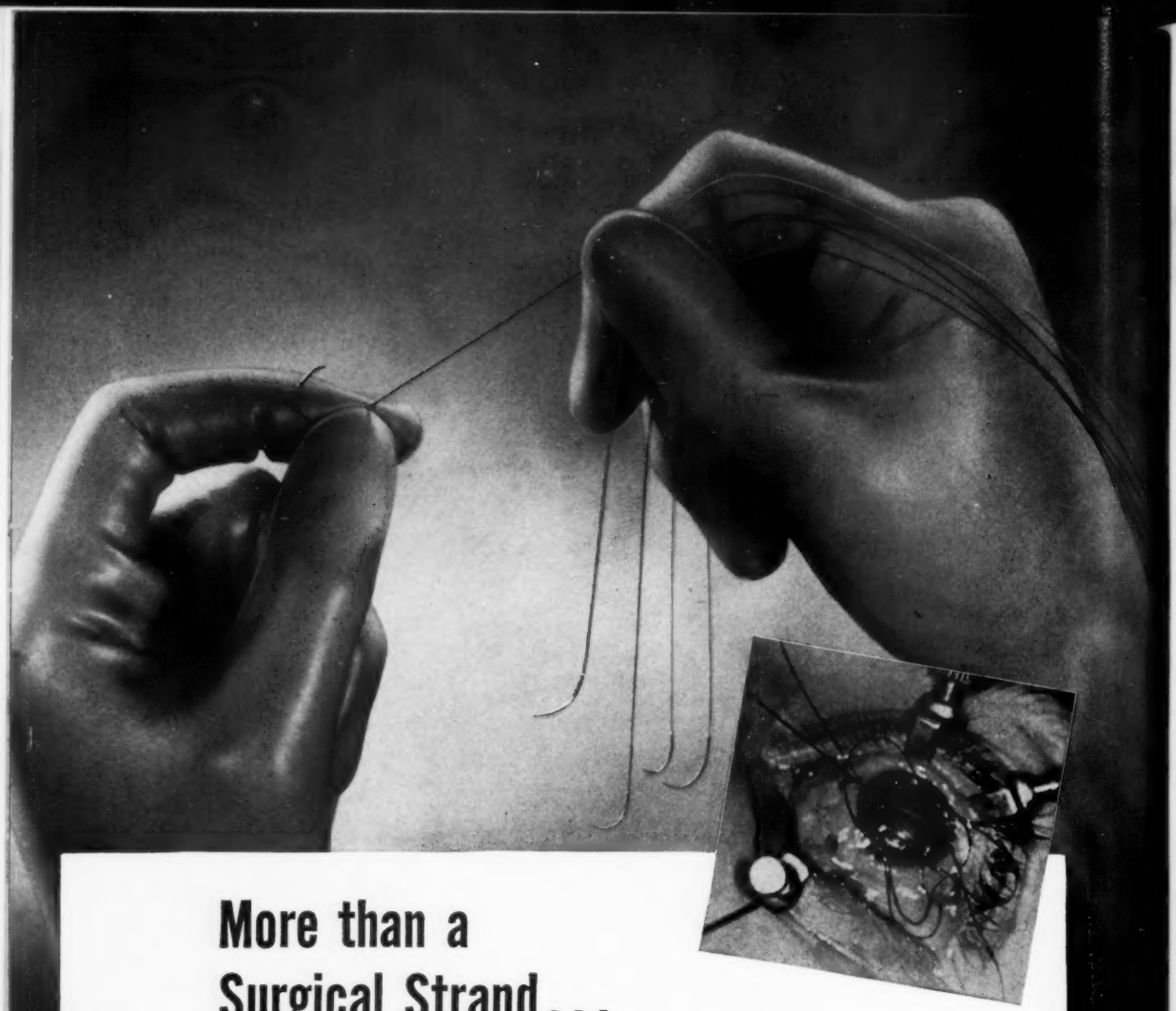

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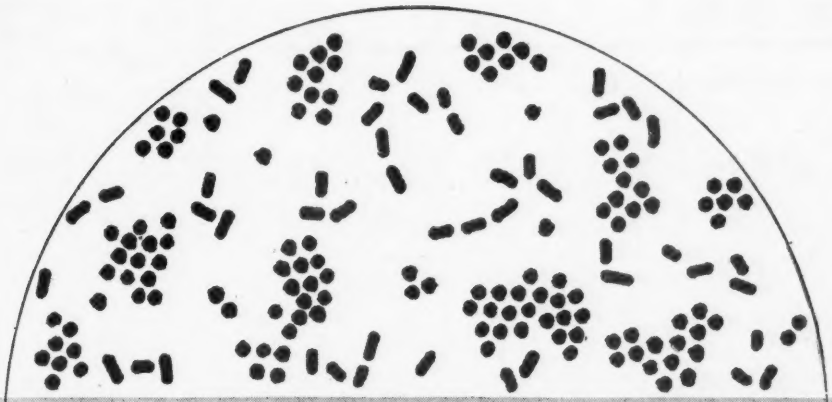

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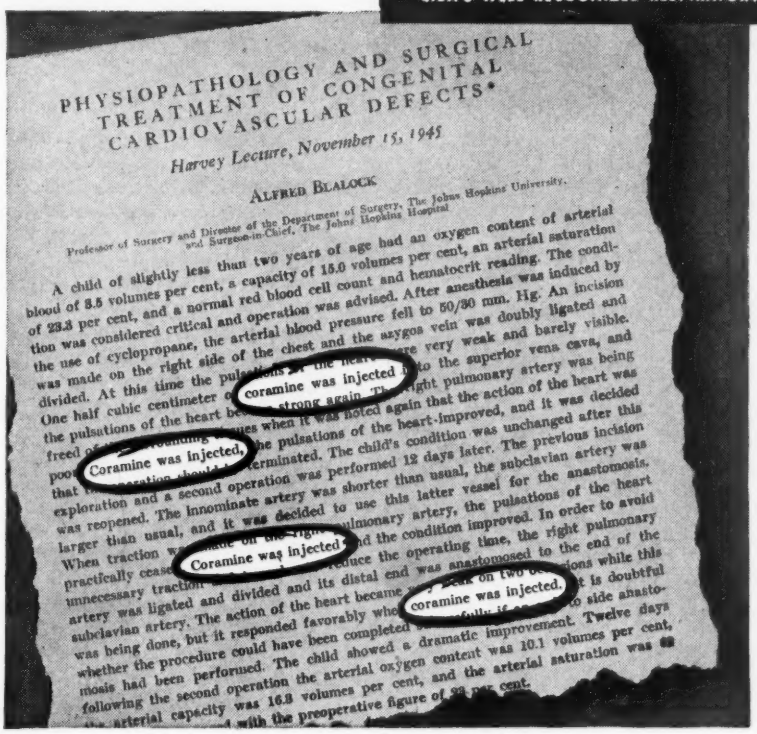

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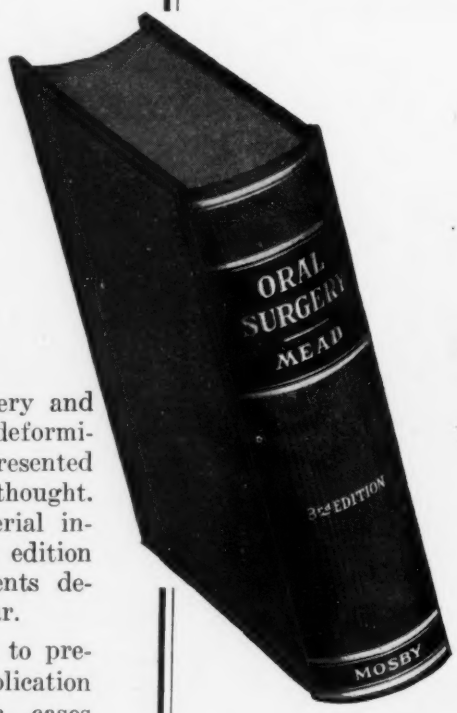

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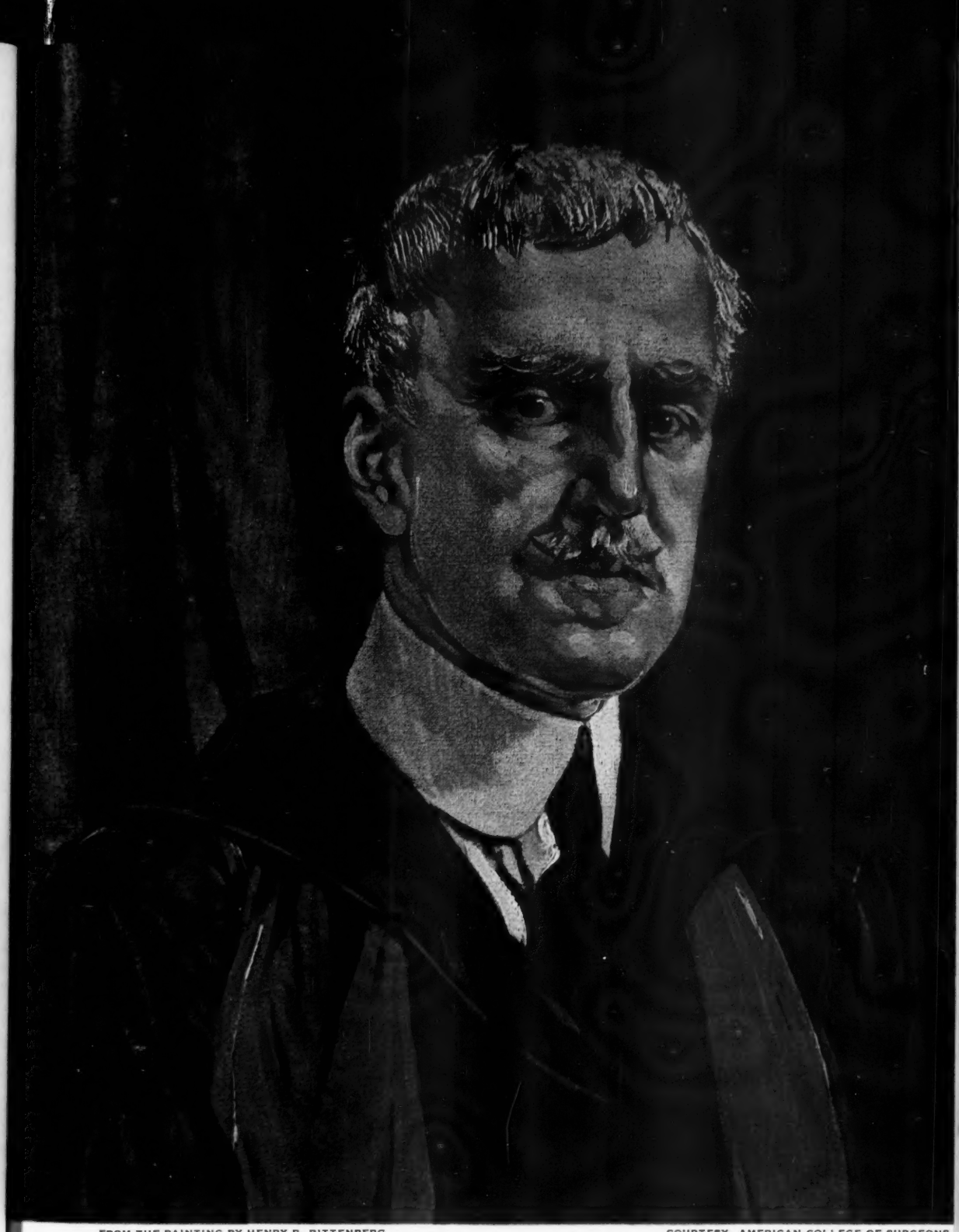

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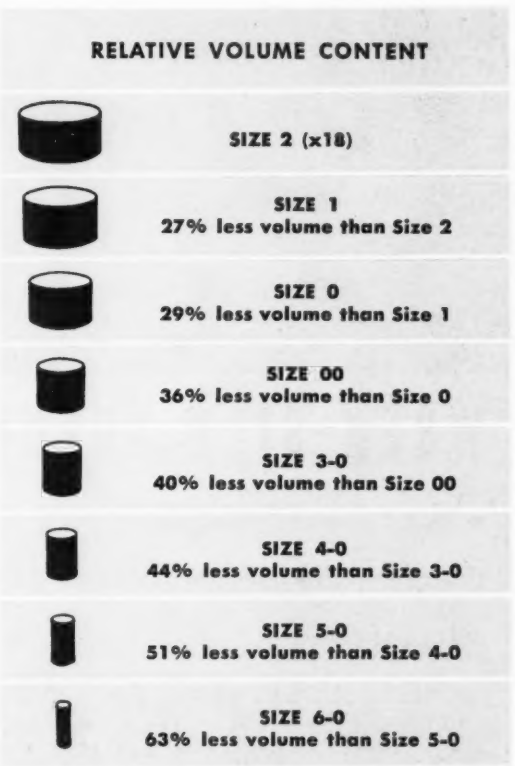

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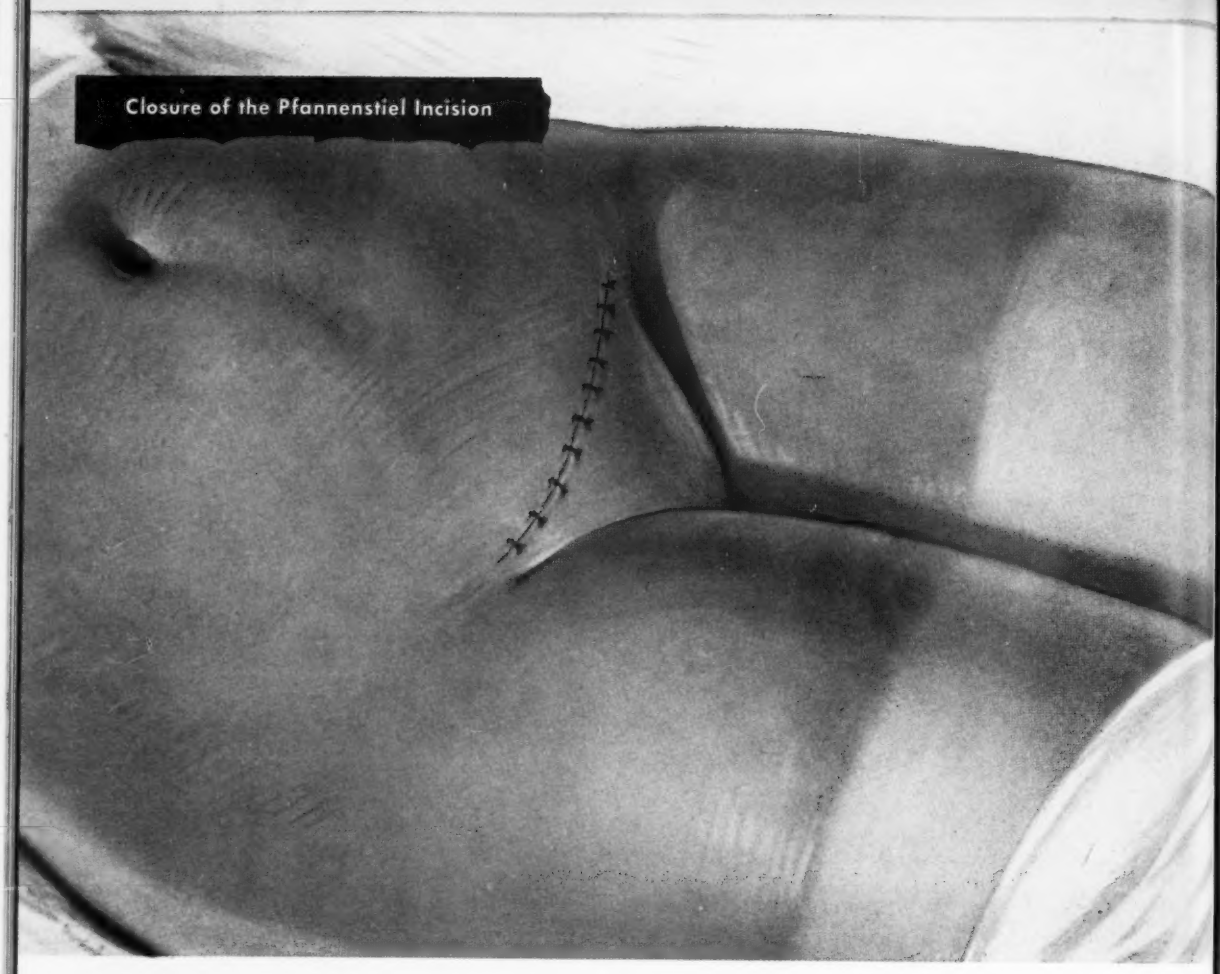

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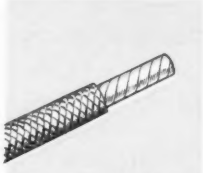

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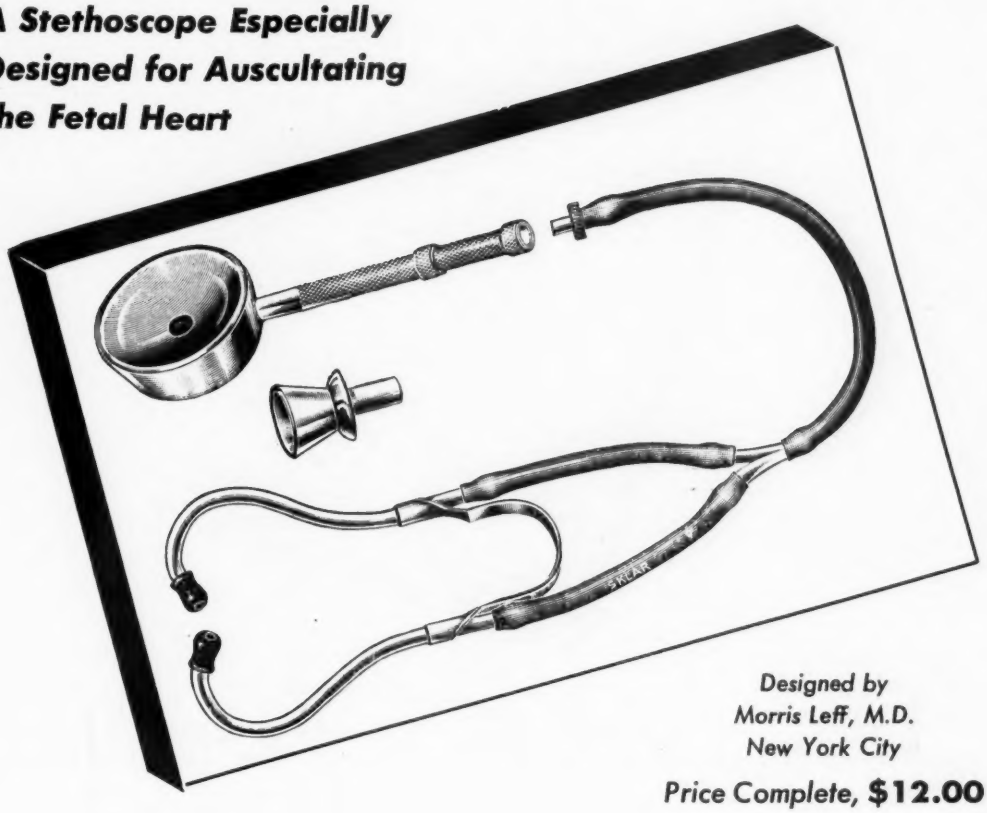

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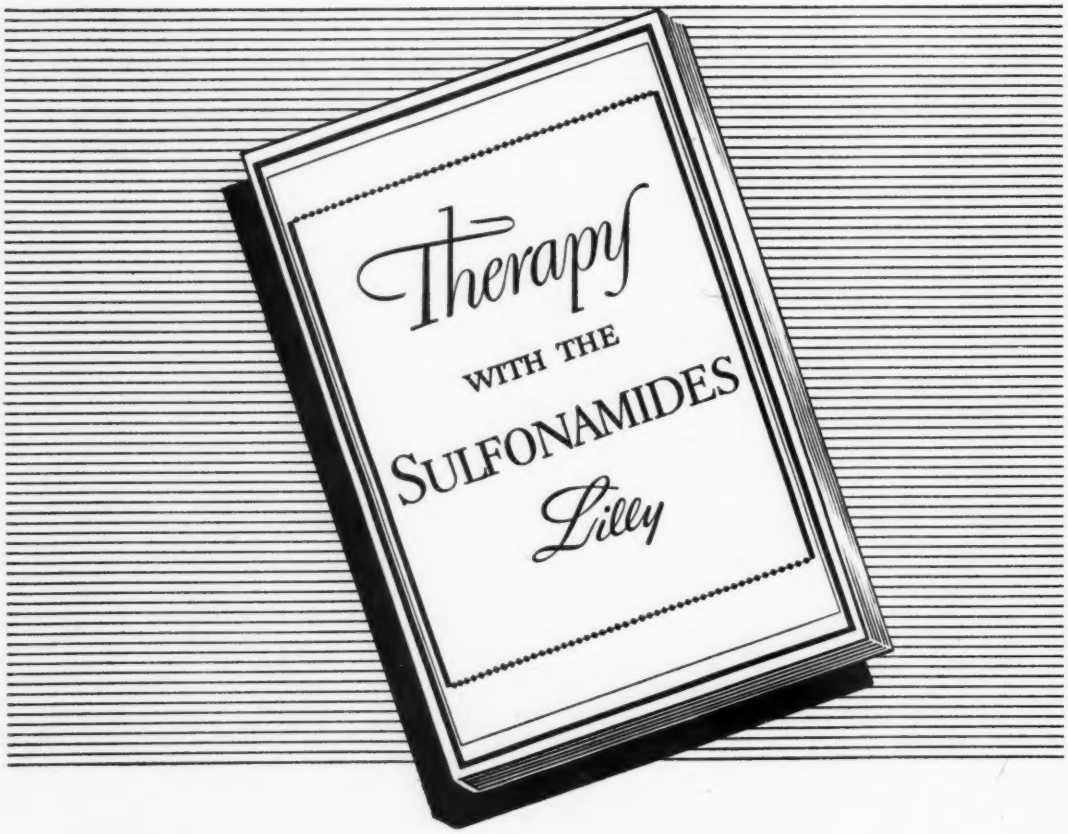

Therapy with the Sulfonamides

In 1937 sulfanilamide was introduced into general clinical use. During the next six years sulfapyridine, sulfathiazole, sulfadiazine, and sulfamerazine followed in rapid succession. The vast clinical literature which has accumulated in the interval has been carefully organized and condensed by the Lilly Research Laboratories into an eighty-three-page book entitled *Therapy with the Sulfonamides*. A bibliography of 323 references is included. The discussion is divided between systemic and local administration. Many helpful charts, including "Sulfonamides in Order of Choice for Systemic Use," "Dosage of Sulfonamides for Adults," and "Dosage of Sulfonamides for Infants and Children," are included. Request a free copy of *Therapy with the Sulfonamides* from the Lilly medical service representative or direct from Indianapolis. Sulfonamides, Lilly, for systemic and local administration are provided in a complete variety of dosage forms, subject to your specifications.

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SURGERY

VOL. 20 OCTOBER, 1946 No. 4

Original Communications

THE USE OF STREPTOMYCIN IN EXPERIMENTAL PERITONITIS

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(From the Harrison Department of Surgical Research, Schools of Medicine, University of Pennsylvania)

THE use of chemotherapeutic agents in the treatment of peritonitis and prophylactically in those conditions in which, in the past, the incidence of peritonitis has been high was attended by substantial reductions in the mortality rates. The use of sulfanilamide in acute appendicitis gave very favorable results in England[2] and also in our own clinic.[6, 7] The local use of sulfonamides as an adjunct to surgery of the large bowel has also been attended by a substantial reduction in mortality.[5, 8] Experimental evidence of the value of sulfonamides in peritonitis goes back to the original experiments of Domagk,[3] who demonstrated the value of these drugs in the treatment of peritoneal infections in mice. The first attempt to reproduce the mixed type of peritoneal infection commonly seen in human pertionitis and to test the effect of sulfonamides on it was that of Bower and his associates.[1] These investigators found a very substantial reduction in mortality following the administration of prontosil. More recently the value of penicillin in experimental peritonitis produced by a modification of Bower's method has been tested by Fauley and his associates.[4] Again the results were gratifying.

The development of streptomycin* by Schatz and his associates[11] and by members of the staff of the Merck Institute has provided an antibiotic which is relatively nontoxic and which, following parenteral administration, becomes widely distributed in body fluids.[9, 15] It is polyvalent to a much greater degree than penicillin or the sulfonamides. Its effectiveness against many strains of organisms of the colon group differentiates it strikingly from penicillin.[10, 11] It was thought that this property might make it an unusually valuable agent in

The work described in this paper was done under a contract, recommended by the Committee on Medical Research between the Office of Scientific Research and Development and the University of Pennsylvania.

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*The Streptomycin was supplied by Merck & Company, Inc., New York, N. Y.

the treatment of acute diffuse peritonitis due to mixed infections with both gram-positive and gram-negative bacteria.

Since the organisms of the colon group are the types most frequently found in the common forms of human peritonitis, it seemed logical to substitute streptomycin for sulfonamides and penicillin. However, before giving up the use of sulfonamides and penicillin, which are drugs of proved if of limited value, it seemed important to test it in experimental peritonitis in dogs.

The experiments to be described in this paper indicate that it is a valuable agent in this condition, although in the dosage used it falls far short of complete effectiveness.

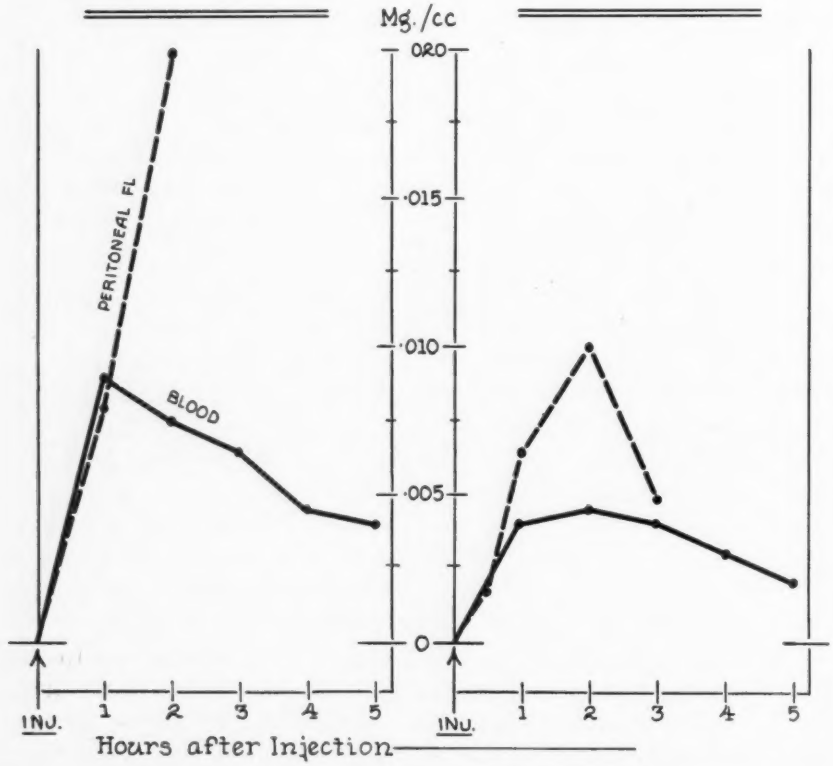

Fig. 1.—Concentrations of streptomycin in blood and peritoneal fluid following single intramuscular injection of streptomycin HCl 100 mg. and single intraperitoneal injection of 200 c.c. physiologic saline solution; single intramuscular injection of streptomycin HCl 50 mg. and single intraperitoneal injection of 200 c.c. physiologic saline solution.

In order to determine whether or not streptomycin would pass into the peritoneal cavity of normal dogs, samples of blood and peritoneal fluid were collected at various intervals following a single intramuscular injection of from 50 to 100 mg. of streptomycin hydrochloride. Immediately before the intramuscular injection of the streptomycin, 200 c.c. of physiologic saline solution were injected into the peritoneal cavity of these animals to insure that fluid could be withdrawn for the peritoneal samples. Blood samples were withdrawn at hourly intervals for five hours and peritoneal samples at one-half hour, one,

two, and, in one animal, three hours following the single injection of physiologic saline solution into the peritoneal cavity. Fluid from the peritoneal cavity was unobtainable after three hours. Streptomycin concentration* was determined by a method described by Stebbins and Robinson.[12] The levels of drug attained are shown in Fig. 1. In order that samples might be obtained for longer periods of time after injection of the drug, further experiments were performed in which physiologic saline solution was injected into the peritoneal cavity immediately after withdrawing each peritoneal fluid sample for assay. Using this method, specimens were obtained hourly for six to eight hours after

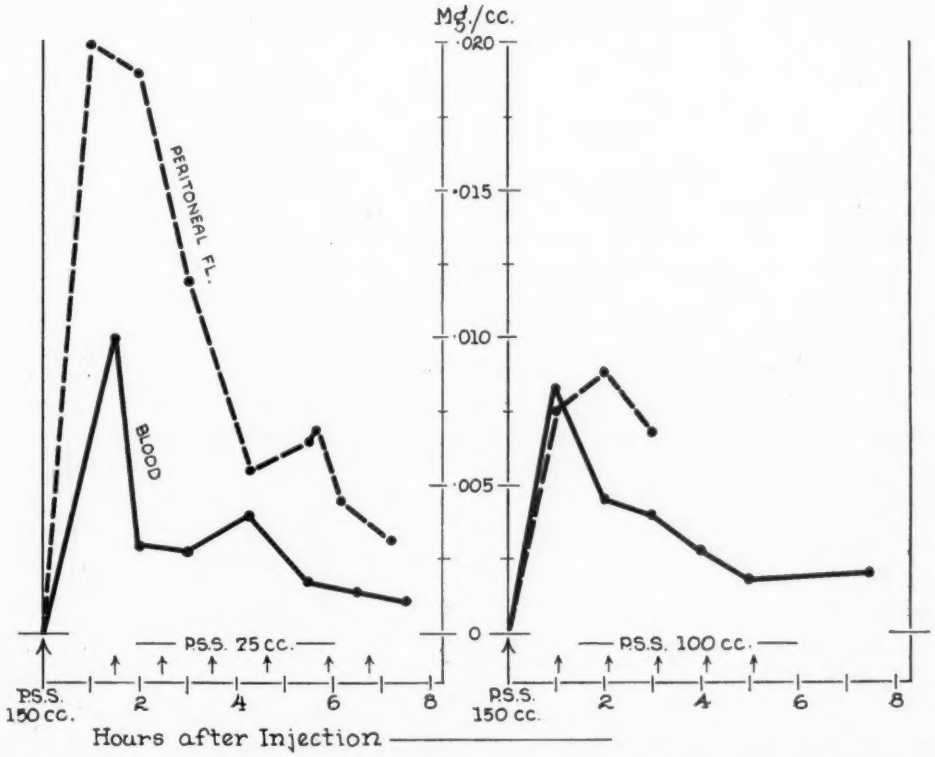

Fig. 2.—Concentrations of streptomycin in blood and peritoneal fluid following single intramuscular injection of streptomycin HCl 100 mg. and interval intraperitoneal injections of physiologic saline solution.

a single injection of streptomycin. In spite of the constant dilution attending the addition of physiologic saline solution to the uninfected peritoneal cavity at hourly intervals, the concentration of the drug in the peritoneal fluid reached, and in most cases surpassed, the concentration in the blood. A detectable concentration persisted in the blood for as long as from seven to eight hours after injection (Fig. 2). This indicates that streptomycin is excreted and/or destroyed much slower than is penicillin.

*Streptomycin concentration is expressed in milligrams according to the conversion factor used by Merck & Company, Inc., wherein 1,000 units are equivalent to 1 mg. of the pure substance.

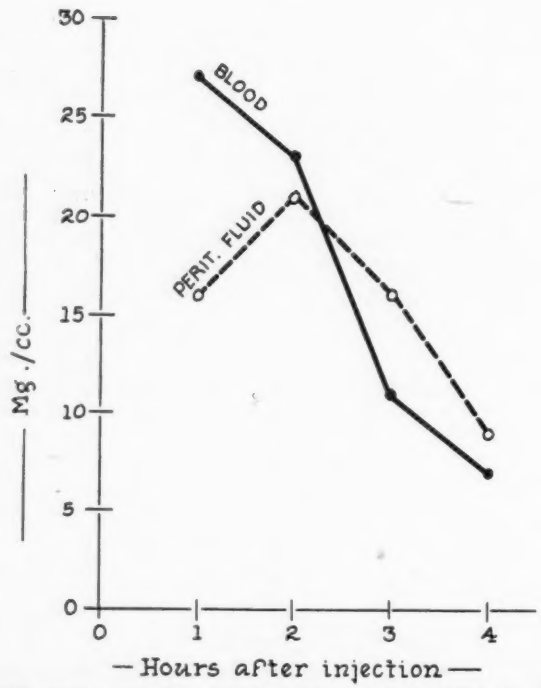

Fig. 3.—Composite graph showing streptomycin concentrations in blood and peritoneal fluid of five animals receiving 75 to 90 mg. streptomycin HCl in distilled water intramuscularly every four hours.

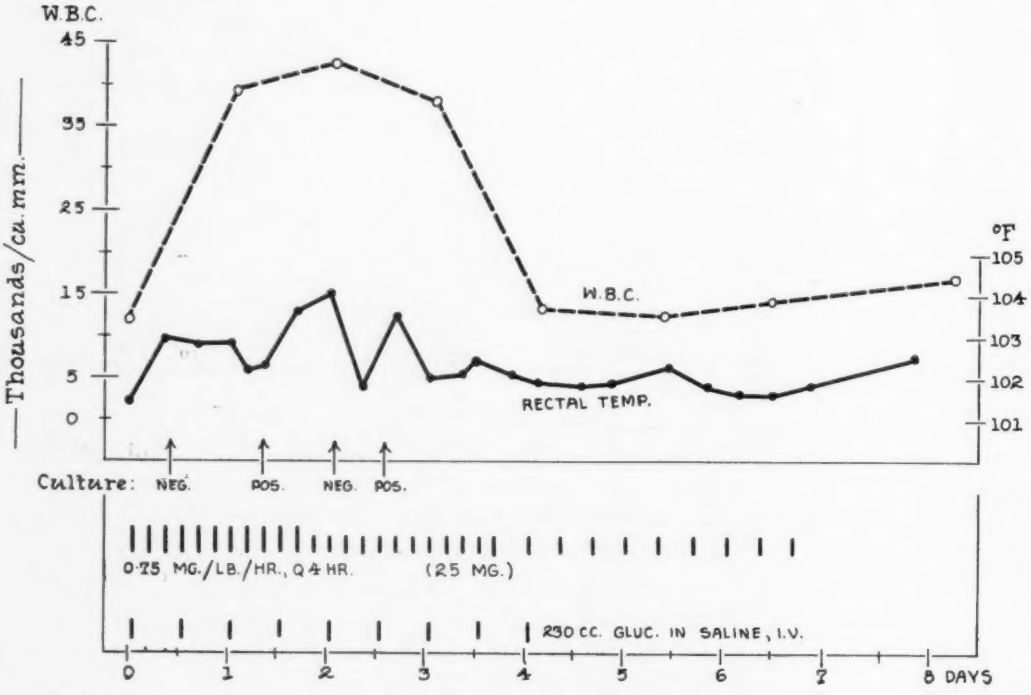

Fig. 4.—Typical course of treated animal.

There is an appreciable amount of streptomycin in the blood and peritoneal fluid four hours after injection of the drug. Thus, when streptomycin is given every four hours, as was done in these experiments, the concentration of the drug shows a cumulative effect. There is shown in Fig. 3 a composite graph of the blood and peritoneal fluid streptomycin levels of five animals receiving between 75 and 90 mg. every four hours. Such repeated doses result in the maintenance of fairly high blood and peritoneal fluid streptomycin levels even after the dose has been decreased. In Table I is given a protocol of a dog treated for forty-eight hours with 85.7 mg. every four hours and then with 25 mg. every four hours for four injections. These data indicate that a fairly high concentration of drug was obtained and maintained in the blood during the entire course of treatment.

TABLE I. ANIMAL TREATED WITH 85.7 MG. OF STREPTOMYCIN HYDROCHLORIDE INTRAMUSCULARLY EVERY FOUR HOURS FOR FORTY-EIGHT HOURS, THEN 25.0 MG. EVERY FOUR HOURS FOR FOUR INJECTIONS

HOURS AFTER LAST INJECTION	STREPTOMYCIN LEVEL IN BLOOD (MG. PER C.C.)
1	0.025
2	-
3	0.010
4	0.008

The technique used to produce peritonitis, in the experiments in which streptomycin was tested, is one which was introduced by Bower and co-workers[1] and modified by Fauley and his associates.[4] The latter technique was followed exactly except that streptomycin was used instead of penicillin. Each animal received 0.75 mg. of streptomycin per pound of body weight per hour every four hours for forty hours, beginning one hour after operation. During the following forty-eight hours 25 mg. were given every four hours, and for the next three days the same dose was administered, but the interval was lengthened to eight hours. The typical postoperative course of such an animal is shown in Fig. 4.

TECHNIQUE

Dogs were selected at random, excluding pregnant dogs, dogs weighing less than twenty-two pounds, and dogs previously operated upon. The animals were starved for twenty-four hours before beginning the experiment. The abdomen was shaved, scrubbed, painted with iodine and alcohol, and draped. Aseptic technique was rigidly observed. Under intravenous nembutal anesthesia (24 mg. of nembutal per kilogram of body weight) the abdomen was entered through a right rectus incision and the appendix drawn into the wound. Mesenteric attachments were divided, and the appendical vessels were clamped, divided, and ligated with fine silk. The base of the appendix was tightly tied with umbilical tape, the viscera replaced, and the wound closed in layers with silk. No drains were used and no dressings applied. Immediately after closure of the wound each animal received 55.0 c.c. of castor oil by stomach tube. This has been shown to stimulate peristalsis and to aid in the perforation of the appendix and spread of infection.[13, 14]

The animals received 10.0 c.c. per pound of body weight of a solution containing 2.5 per cent glucose and 0.45 per cent saline intravenously immediately after operation and every twelve hours thereafter for five days or until death. Rectal temperatures were recorded every eight hours and the white blood cell count was recorded every twelve hours. The animals received nothing by mouth for the first four days. Necropsy was performed on all fatalities shortly after death. The animals that survived were examined not earlier than twenty-one days after operation. All animals operated on are included in the series. Animals living twenty days were considered to have recovered.

Ten animals were used as controls. Of these, seven died of acute diffuse peritonitis within five days after operation; three recovered, a mortality of 70 per cent. In the experiments of Fauley and co-workers,[4] twenty-five of twenty-seven control animals died, a mortality of 92.6 per cent. The typical postoperative course of one of our controls is shown in Fig. 5.

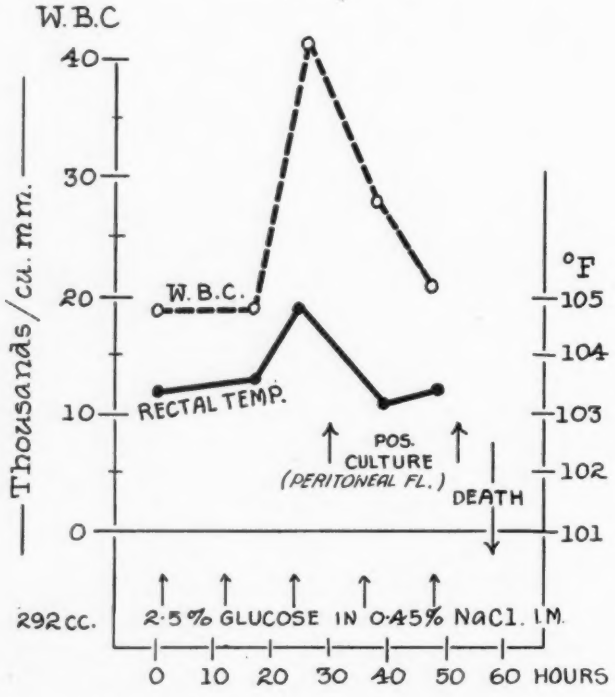

Fig. 5.—Typical course of control animal.

Ten animals were treated with streptomycin in the manner described. Of these, four died within forty-nine hours after operation of acute diffuse peritonitis. Six animals lived more than twenty days postoperatively. Thus, the mortality in the treated animals was 40 per cent. The results are difficult to compare with other series[1, 4] because of discrepancy in the control mortality. The survival rate of the treated animals compares favorably with that obtained by other methods of treatment.[1, 4] It is believed that streptomycin may be of value in the treatment of peritonitis since high concentrations of the drug are obtained

in the peritoneal fluid and since the mortality in this series indicated that approximately 60 per cent of the animals treated may survive when streptomycin is administered. It is realized that the dosage used in these experiments does not represent the maximum dosage that can safely be administered.

CONCLUSIONS

1. Streptomycin was found in significant amounts in the peritoneal fluid of normal dogs and dogs with acute diffuse peritonitis.

2. The survival rate of the control animals was 30 per cent as compared with a survival rate of 60 per cent for the streptomycin-treated animals.

REFERENCES

1. Bower, J. O., Burns, J. C., and Mengle, H. A.: Prontosil and the Treatment of Spreading Peritonitis in Dogs, J. Lab. & Clin. Med. **24**: 240, 1938.
2. Corry, D. C., Brewer, A. C., and Nicol, C.: Postoperative Treatment of Appendicular Peritonitis With Sulfanilamide and Its Derivatives, Brit. M. J. **2**: 561, 1939.
3. Domagk, G.: Ein Beitrag zur Chemotherapie der bakteriellen Infektionen, Deutsche. med. Wehnschr. **61**: 250, 1935.
4. Fauley, G. B., Duggan, T. H., Stormont, R. T., and Pfeiffer, C. C.: The Use of Penicillin in the Treatment of Peritonitis, J. A. M. A. **126**: 18, 1944.
5. Lockwood, John S., and Ravdin, I. S.: The Prophylactic Use of Sulfanilamide in Abdominal Surgery, SURGERY **8**: 43, 1940.
6. Lockwood, J. S., and Rhoads, J. E.: The Use of Sulfanilamide in the Treatment of Peritonitis, S. Clin. North America **19**: 1457, 1939.
7. Ravdin, I. S., Rhoads, J. E., and Lockwood, J. S.: The Use of Sulfanilamide in the Treatment of Peritonitis Associated With Appendicitis, Ann. Surg. **3**: 53, 1940.
8. Ravdin, I. S., Lockwood, J. S., and Rhoads, J. E.: Symposium on New Trends in Surgery; the Results of Sulfonamide Prophylaxis in the Surgery of the Large Bowel, S. Clin. North America **22**: 1585, 1942.
9. Robinson, H. J., Graessle, O. E., and Smith, D. G.: Studies on the Toxicity and Activity of Streptomycin, Science **99**: 540, 1944.
10. Robinson, H. J., Smith, O. G., and Graessle, O. E.: Chemotherapeutic Properties of Streptomycin, Proc. Soc. Exper. Biol. & Med. **57**: 226, 1944.
11. Schatz, A., Bugie, E., and Waksman, S. A.: Streptomycin. A Substance Exhibiting Antiobiotic Activity Against Gram-positive and Gram-negative Bacteria, Proc. Soc. Exper. Biol. & Med. **55**: 66, 1944.
12. Stebbins, R. B., and Robinson, H. J.: A Method for Determination of Streptomycin in Body Fluids, Proc. Soc. Exper. Biol. & Med. **59**: 255, 1945.
13. Steinberg, Bernard: Infections of the Peritoneum, New York, 1944, Paul B. Hoeber, Inc.
14. Steinberg, B., and Martin, Ruth: Diffusion and Localization of Experimental Infections of the Peritoneum, Surg., Gynec. & Obst. **79**: 457, 1944.
15. Zintel, H. A., Flippin, H. F., Nichols, A. C., Wiley, M. M., and Rhoads, J. E.: Studies on Streptomycin in Man. I. Absorption, Distribution, Excretion, and Toxicity, Am. J. M. Sc. **210**: 421, 1945.

TRAUMATIC ANEURYSMS

A Study of Forty-three Cases in an Overseas General Hospital

Lieutenant Colonel Hollis L. Albright and Major Laurence A. Van Hale
Medical Corps, Army of the United States

EXPERIENCES with vascular injuries early and late have mounted steadily during the progress of World War II, in a striking parallel to those recorded by the surgeons of World War I. Recognition that their problems were similar, that their management was good, and essentially the same, did much to dispel the confusion present in our approach to the care of these patients. The Royal Society of Medicine Library in London readily provided a list of over 100 publications on traumatic aneurysms alone, appearing between 1915 and 1920.

As the wounded soldier was evacuated to the Vascular Centers in the Zone of Interior, in each medical installation these pulsating vascular injuries had to be evaluated and promptly recognized and necessary measures of control of complications that might endanger the soldier during his further transit, instituted.

Case 1 is reported to illustrate some of the severe complications commonly confronting the patient with a traumatic aneurysm.

CASE REPORT

Case 1.—A 21-year-old paratrooper sustained a penetrating shell fragment wound of the left upper posteromesial thigh six hours after jumping into France on D-Day. Profuse bleeding was controlled by a pressure dressing. Sulfadiazine and penicillin were begun on the evacuation beach.

On his arrival at the general hospital, seven days later, the débrided wound was unremarkable, and the general condition was good. Roentgenogram revealed a 10 by 8 mm. fragment in the anterior mid-thigh.

Ten days after injury severe secondary hemorrhage of approximately 1,000 c.c. required emergency control by pressure, transfusions of blood and plasma, and exploration of the wound. The profunda femoris vessels were intact. The wound was lightly dressed with petrolatum gauze.

On the twenty-fourth day an expansile swelling and palpable thrill were noted over the femoral vessels in the upper third of the thigh. A diagnosis of arteriovenous aneurysm of the superficial femoral artery and vein was made.

Dusky cyanosis of the dependent leg was noted on the thirty-ninth day. There was no pain.

On the sixty-fourth day, while awaiting evacuation to the United States, the patient complained of steady severe pain. The mass had enlarged, become more tense, and extended down the inner thigh.

Quadruple ligation of the femoral artery and vein distal to the profunda femoris vessels was done on the sixty-fourth day after injury. A large aneurysmal sac, 18 by 12 by 10 cm., filled with clot, was excised together with the vessel segments (Fig. 1). The foreign body was removed. Daily paravertebral blocks gave but temporary improvement in the cool, ischemic foot with cyanotic toes. On the fourth postoperative day, a left lumbar sympathectomy was done, with removal of the third, fourth, and fifth ganglia. The foot became strikingly warm and recovery henceforth was uneventful (Fig. 2). At the time of his return to the Zone of Interior, fifty-six days later, he was symptom free.

Received for publication, Oct. 11, 1945.

General Considerations.—Forty-three patients with aneurysms were studied in this general hospital in England during the eleven months from D-Day June 6, 1944, to V-E Day May 8, 1945. No patient had more than one aneurysm.

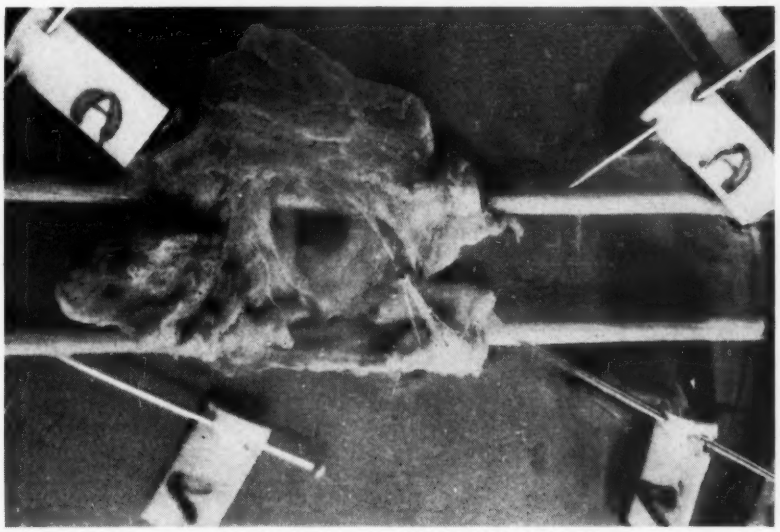

Fig. 1.—Arteriovenous aneurysm of the superficial femoral artery and vein, from the upper third of the thigh. Note the central communication which led to the large clot-filled aneurysmal sac, 18 by 12 by 10 cm.

Fig. 2.

Fig. 3.

Fig. 2.—The patient (Case 1) four weeks after excision of the aneurysm and postoperative lumbar sympathectomy on the fourth day. The patient was symptom free and there was no edema.

Fig. 3.—Patient with signs of congenital aneurysm that is ductus arteriosus. Tiny shell fragment wound sustained over sternum. No evidence of intrathoracic foreign body or injury. The patient was sent to the hospital because of traumatic arteriovenous aneurysm. Area of harsh to-and-fro bruit is outlined.

There were twenty-three arterial and twenty arteriovenous in type. Fourteen patients (three with arterial and eleven with arteriovenous aneurysms) were returned to the Zone of Interior without operation, because the aneurysm was regarded as relatively stabilized and free from complications. Nine patients previously operated upon in forward institutions were studied postoperatively. Twenty patients (eleven with arterial and nine with arteriovenous aneurysms) were operated upon in this general hospital. One patient (Fig. 3) sent to the hospital because of a traumatic intrathoracic aneurysm was found on study to have a congenital aneurysm. This explained the harsh to-and-fro murmur over the great vessels, following a tiny superficial shell fragment wound over the sternum, with no opaque intrathoracic foreign body and no possible wound of exit.

The policy of delay in treatment of the uncomplicated aneurysm in order to allow development of the collateral circulation, as advised by War Department Circular No. 235, June 12, 1944, and as generally advised by American and British surgeons (Holman,[1, 2] Elkin,[3] Pemberton and Black,[5] Bigger,[6] Maybury,[7] and Ogilvie[8]), was followed. Attention was directed (1) toward accuracy of diagnosis, (2) to the timing of necessary surgical intervention, (3) to the importance of specific preoperative studies and treatment, (4) to the operative technique, and (5) to postoperative measures guarding against limb mortality and morbidity.

A missile, shell fragment, or bullet passing through a vessel either divides it completely or partially transects the wall. The completely divided vessel requires early treatment. Most patients will bleed to death unless a tourniquet is applied or the vessel secured. Amputation may be necessary later. These patients do not develop pulsating hematomas or their later counterpart, traumatic aneurysms.

Partial division of an artery, or artery and vein, if treated expectantly, and it usually is, will lead to the development of a pulsating hematoma, thence to a traumatic aneurysm. The spasm in the vessel causes the rent in the wall to gape, and the vessel continues to bleed into the tissues. Bleeding ceases only when the pressure in the hematoma is equal to the arterial pressure of the involved vessel. The amount of bleeding and the size of the hematoma depend on the resistance of adjacent tissues and upon the size of the artery. The more tense the tissue planes the smaller the hematoma. A clot may temporarily seal the gap in the vessel wall, only to give way days or weeks later. Similarly, a contused portion of the wall may later give way (Maybury[7]). If the wound is large and gaping the vessel must be secured to prevent fatal hemorrhage, and the patient will not develop a pulsating hematoma.

The pulsating arterial hematoma is seen typically as a firm, tense, moderately tender, painful, throbbing mass. It was smaller, less tense, tender and painful in the arteriovenous group, and its complications were fewer. Both types undergo similar changes during their transformation into an aneurysmal sac. The distal vessels usually remain patent. The central portion of the hematoma sooner or later becomes liquid and a pulsation appears. Organization of the

clot begins at the periphery eventually, to form in four to six weeks the endothelially lined sac membrane. There may be some ingrowth of collateral vessels, especially in the arteriovenous aneurysm. Contamination and infection may interfere with the deposition of firm fibrous tissue and permit of softened areas in the sac membrane predisposing to rupture. This may cause further hemorrhage, swelling, damaging pressure upon the collateral and main blood supply and upon adjacent nerves, leading to ischemia, gangrene, and severe sensory or motor disturbances. Infection must always be considered since all wounds are contaminated by the passage of the missile, and occasionally pieces of clothing, through the soiled perspiring skin.

Once the clot is absorbed and the sac membrane formed, the lesion becomes a traumatic or false aneurysm. This differs from a true aneurysm in that the wall of the aneurysmal sac is not made up of the three layers of the normal vessel wall, but only of lining endothelium and peripherally organized clot.

Thus, the pulsating hematoma is the precursor of all traumatic aneurysms. It is most characteristic in the patient with the arterial injury, and less characteristic and smaller in the patient with the arteriovenous injury. It will lead inevitably, in days or weeks, to a traumatic aneurysm. Operation is always required sooner or later, especially if the hematoma ruptures and exerts damaging pressure upon the adjacent structures.

In this series many diagnostic terms had been employed to describe these two basic lesions, the *traumatic arterial aneurysm* and *traumatic arteriovenous aneurysm*. The term pulsating hematoma is descriptive of a traumatic aneurysm, in its early stages. In fact, the hematoma is aneurysmal once it starts to pulsate, since its central portion then contains rhythmically flowing blood. Henceforth, for simplification and clarity, the terms arterial aneurysm and arteriovenous aneurysm will be used. The pulsating hematoma will be regarded as an early phase in the development of both.

A fistula alone is less commonly seen. An associated hematoma is nearly always present. It was demonstrable in all except the three patients with intrathoracic arteriovenous lesions. The simple fistula is seen more commonly in the congenital (ductus arteriosus), the mycotic aneurysm, and the very long-standing traumatic cases, wherein the sac opening may have been small and eventually obliterated by thrombosis and fibrous replacement.

The traumatic aneurysm was thought to be arterial alone, until 1757, when William Hunter[9] first recognized an arteriovenous aneurysm as a direct communication between artery and vein. Holman,[1] in his prize-winning monograph, has given an extremely helpful review of the subject of arteriovenous aneurysm. Earlier surgeons at first ligated the proximal artery (the hunterian operation), only to meet with gangrene. Bramann,[10] in 1886, analyzing 159 cases concluded that this ligation of the artery proximal to the fistula must be absolutely condemned. The collateral circulation will find its way into the fistula and not into the distal capillary bed. He favored quadruple ligation of the artery and vein with extirpation or plication of the sac. If the artery and vein are ligated proximally alone, this will be of temporary benefit, for the fistula will not be

cured. Again, collateral channels will readily send blood through the fistula rather than distally.

Quadruple ligation with excision of the aneurysm was advised by the Inter-allied Conference of Surgeons in Paris, in May, 1917, and is generally regarded as the procedure of choice, especially in the young patient of soldier's age. Ligation of the accompanying vein, even though uninjured, was recommended, to retard too rapid venous outflow from the limb. Additional methods may help the surgeon in certain instances. Quadruple ligation without excision may prove wisest when there is an ill-defined sac membrane and widespread inflammatory fibrosis. The intrasaccular method of obliterative endoaneurysmorrhaphy of Matas,[11] which he first reported in 1888, and the transvenous closure of the fistula are well-known and useful methods. In addition, attempts have been made to restore the blood flow through an injured major vessel, or at least to keep up the flow temporarily until an adequate circulation has been established. Paraffinized cannulae were used with some success by Tuffier[12, 13] in 1915. The use by Blakemore, Lord, and Stefko,[14-16] since 1942, of vitallium tubes lined with a vein graft has proved encouragingly effective in animals and in two clinical patients. The suture of arterial wounds, anastomosis of severed arteries, and closure of fistulas between arteries and veins have in the past been hampered by thrombosis at the suture lines. Thrombosis has occurred, too, in the past within the cannulae. Heparin and dicoumarin are now available to minimize and prevent this complication. Vascular centers in both the forward and rear areas have been set up where these traumatic aneurysms can best be dealt with under most advantageous conditions.

Interruption of sympathetic pathways temporarily with novocain paravertebral block, and less commonly by permanent ablation, has been found increasingly useful in the treatment of the ischemic limb. Experience has supported the view that when ligation of a main artery in an extremity is inevitable, the risk of gangrene can be reduced by preliminary sympathectomy (Learmonth[17] and White[18]), or by repeated paravertebral sympathetic block with novocain postoperatively. This releases vasospasm and allows the collateral channels to dilate. Gage[19] reported the real value of developing and maintaining the collateral circulation in fifteen patients with arterial and arteriovenous aneurysms by either injection or ablation of the regional sympathetic ganglia. Veal[20] suggested that sympathectomy may prove additionally of value in the future nutrition of the limb, stating that with a leg at rest, in a warm environment, the circulation may be adequate and the patient symptom free; but it may be wholly inadequate under the stress of normal function and fluctuations in climate.

Collateral circulation must develop and enlarge by active growth. Capillaries must become arterioles and venules; gaps of lacerated tissues have to be bridged and repaired; the woody fibrous mass surrounding the hematoma of the aneurysm must be absorbed and infection overcome. Such repair takes time and must be allowed for in planning operations on traumatic aneurysms. When the collateral circulation is established, there is much to be said for deliberate

dilatation of the collateral vessels by sympathectomy. This plan followed in the Middle East and backed by other modern methods of caring for the ischemic limb has been giving excellent results.[21]

The British Center for Vascular Injuries has sent the following instructions to the forward areas, to develop three principles (Ogilvie[8]):

1. To bring the circulation to its maximum efficiency
2. To direct the blood current selectively toward the threatened limb
3. To reduce the demand of the starved tissues for oxygen to the lowest level compatible with survival

The instructions were as follows:

(1) Restore the blood volume and hemoglobin to normal by transfusion.
(2) Inject 250 c.c. of sodium chloride 2 per cent solution into a vein.
(3) Keep the limb below the level of the heart.
(4) Warm the body but keep the threatened limb cool by exposing it to air.
(5) Infiltrate the stellate or lumbar ganglia with novocain.
(6) Resect the ganglia, prior to a secondary operation on an artery, as for aneurysm.

Simultaneous ligation of the vein is advised against, not because it is felt to be wrong, but because the only advantage it gives is believed to lie in passive congestion of the capillary bed, an effect that can be gained more simply by posture. Homans[22] agreed with this, stating that ligation of the companion vein hitherto regarded as essential may prove to be of less importance than intermittent depression of the wounded limb. Lowering the limb 4 to 6 inches below the heart level elevates the venous pressure in the extremity just enough to keep the collateral supply of blood sufficiently long for complete deoxygenation (Blakemore and Lord[16]).

Bigger[6] in a study of twenty-nine cases emphasized the likelihood of residual circulatory insufficiency. This has been noted in a high percentage of cases followed. He agreed that excision of the sac and quadruple ligation are the procedure of choice, guarding against recurrence of the fistula. However, he deplored the inevitable sacrifice of collaterals in excising the sac. He suggested that transvenous repair of the larger arteries be done if there are no contraindications, notably calcification of the vessel wall. This has been observed by x-ray within a few weeks of injury (Schroeder[23]). Bigger believed that interruption of the sympathetic nerves may help prevent chronic circulatory deficiency distal to the ligation of the main vessel.

In World War II, Gnilorybov[24] on the Russian front reported his experience with 130 personally performed operations, 98 for "aneurysm" and 32 for pulsating hematoma. Ligation was done in two-thirds of the operations and suture in the remainder. No gangrene followed suture, whereas gangrene developed in 10 per cent of the ligations. Punin was quoted in a series of over 1,000 cases; he found little difference (7 per cent gangrene) with each method. Apparently no anticoagulants were used with arterial suture.

Killian[25] discussed the experience of the German surgeons on the Russian front with eighty-three fresh traumatic aneurysms, of which 72 patients were operated upon within twelve days. Of the seventy-two operated upon, thirteen died (18 per cent mortality), six because of the wrong diagnosis, that is the aneurysm was opened into, in the belief that it was an abscess. Arterial suture, end-to-end, with a vein graft where necessary was attempted in most cases, using ligation as a second choice. Amputation for hemorrhage and gangrene was necessary in a considerable, unstated, number of cases. The diagnosis was missed in eleven of the eighty-three cases. It was often missed because there was no record of the distal pulses having been examined, even though the injuries were close to large vessels. This high incidence of patient and limb mortality hardly seems to justify the conclusions advising early rather than delayed operations and arterial suture without anticoagulants in preference to ligation. Such is at radical variance with the established experience of surgeons of the allied countries.

Differential Features.—The symptoms are few and may be common to both types. Pain is moderate, usually throbbing or buzzing in character. Claudication, coldness, weakness, and easy fatigability of the extremity, with paresthesias due to ischemic neuritis or paralysis due to pressure may be present. Severe, unremitting pain means impending complication. Shortness of breath is usually a later symptom in the arteriovenous patient.

The findings differ characteristically, however (Table I). Both types are evidenced by an expansile pulsating tumor (Figs. 4 to 6). In the arterial aneurysm a thrill may or may not develop. It was present in eight of our twenty-three patients. The pathognomonic systolic bruit was present in all. There was little to no change in temperature of the extremity. The distal pulses and blood pressure are usually unchanged, unless the size of the hemotoma mechanically occludes the artery. Compression of the proximal artery causes no slowing of the pulse or rise in blood pressure. The distal venous pressure usually shows no change. Ischemic neuritis may be present.

The arteriovenous aneurysm is characterized by a usually smaller and less tense swelling, a tremulous thrill, and a to-and-fro murmur with systolic accentuation. The larger the fistula the more pronounced is the thrill (Hol-

TABLE I. DIFFERENTIAL CHARACTERISTICS

ARTERIAL ANEURYSM	ARTERIOVENOUS ANEURYSM
Expansile mass usually larger, more tense, and tender	Expansile mass, usually small, less tense, and tender
Thrill inconsistent (8 of 20 cases)	Thrill, usually marked, present in all but the ductus arteriosus case
Systolic bruit	Continuous bruit with systolic accentuation
Distal pulse usually unchanged	Distal pulse diminished to absent
Distal blood pressure unchanged	Distal blood pressure showing marked drop
Temperature unchanged	Usually increased warmth of extremity
Pulse and systemic blood pressure little to no change	Usually moderately increased
Compression of proximal artery causes no slowing of pulse or rise in blood pressure	Compression of fistula on proximal artery causes immediate slowing of pulse and slight rise in blood pressure
Distal venous pressure unchanged	Distal venous pressure increased
Distal venous blood oxygen and carbon dioxide unchanged	Oxygen increased, carbon dioxide decreased

man[1]). The thrill is produced by arterial blood under higher pressure coming suddenly in contact with low pressure venous blood, creating whirling eddies readily discernible through the vein wall at operation. The distal pulse is diminished to absent and the distal blood pressure definitely reduced. The extremity may be at first cool but usually shows increased warmth as the collateral channels develop. Compression of the fistula (Marey, 1859[1]) or of the proximal artery (Nicoladini, 1875[1]) causes characteristic slowing of the pulse, with less marked rise in the systemic blood pressure (Gunderman, 1915[1]). This proved a valuable differential sign.

The systemic effects are slight with the arterial aneurysm. They may be considerable in the patient with arteriovenous aneurysm, depending on the size, location, and duration of the fistula. The larger and more central the fistula and the longer it exists, the more likely cardiovascular changes are to develop. Reid[26] first reported cases in which the circulatory effects of the fistula had resulted directly in cardiac decompensation and death. There was tachycardia in four of our patients but no demonstrable cardiac dilatation or hypertrophy.

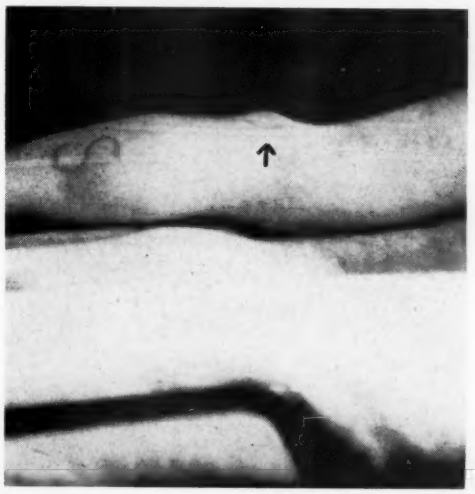

Fig. 4.—A small arteriovenous aneurysm of the popliteal vessels, with the patient prone.

Rarely the carbon dioxide and oxygen content of blood from a vein near the lesion is necessary to distinguish definitely between the two. Some confusion may arise when the lesion is deep-seated or is surrounded by inflammatory thickening or extravasated blood (Pemberton and Black[5]). Dilated pulsating superficial veins have been described, but were not encountered in our twenty cases. Only at operation was the involved vein seen to pulsate.

In this series, study at the bedside with classifying charts yielded an unsuspected amount of helpful data. Except for desirable thoroughness, little additional value was gained from arteriography, phlebography, or venous pressure readings. No studies of the distal venous blood oxygen and carbon dioxide levels were made. Arteriography was used but twice. At the common femoral level, with direct operative exposure, the procedure was moderately extensive

and traumatic. It added little in determining the location and actual size of the fistulous opening. Phlebography was used twice to confirm the absence of a fistula.

No examination was considered complete without palpation of each wound for pulsation and thrill, and auscultation for bruit. This led to the discovery of unsuspected aneurysm in six patients. In five patients examination at intervals revealed the development of an arterial hematoma during their hospital stay. Such examination prevents small aneurysms from being overlooked and may avoid making the wrong diagnosis of abscess. Six deaths resulted from mistakenly opening into these "abscesses" in Killian's[25] series of seventy-two early operations upon German soldiers on the Russian front. Nothing can lead

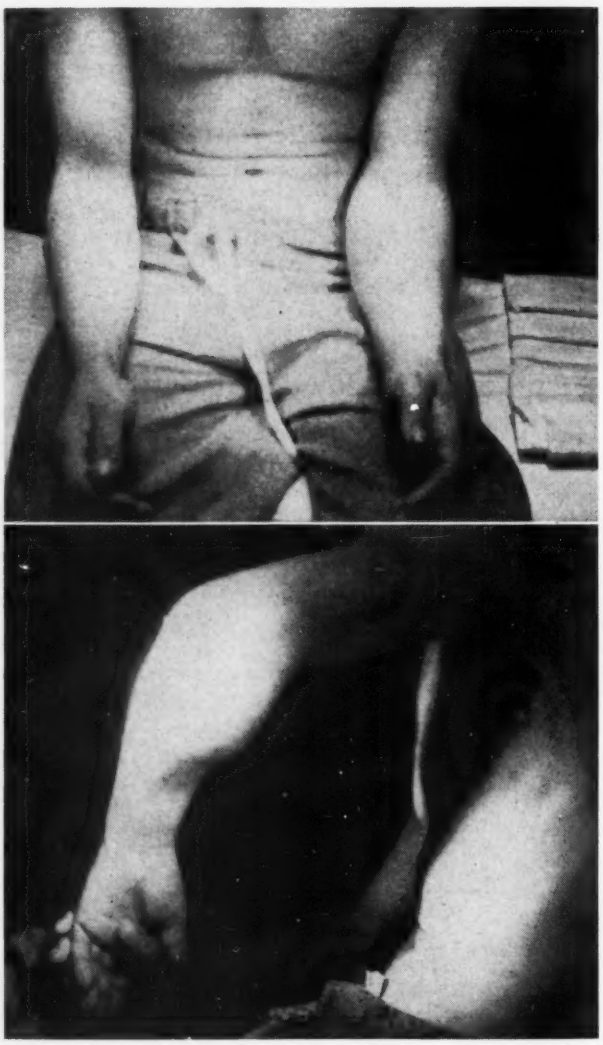

Fig. 5.—An arterial hematoma of the brachial artery. Brawny edema, cyanosis, and paresthesias were present. Uneventful recovery followed quadruple ligation of the brachial vessels with evacuation of the hematoma.

to such a distressing situation creating an unavoidable emergency for which no preparation has been made. In the first case in this series, the only nonbattle injury, namely, a soldier who had sustained a gunshot wound through the shoulder one month previously, a mistaken diagnosis of axillary abscess was made. It was opened into with nearly fatal, exsanguinating hemorrhage. The subclavian artery could not be digitally compressed successfully with the arm abducted. We have confirmed this repeatedly since, in our tests of the collateral circulation of the arm. Once the arm was brought to the side the subclavian vessels were more on the stretch and could be compressed readily against the

Fig. 6.—An arterial aneurysm of the brachial artery, seven weeks after injury. The course of the bullet is indicated. There was fixation of the elbow at 90 degrees, with hemorrhagic infiltration of the median nerve and distortion by pressure. The contracture was difficult to correct postoperatively.

first rib, with control of the hemorrhage. Following ligation of the second portion of the axillary artery, the patient happily made an uneventful recovery. Davis[27] mentioned operating upon a painful brachial mass in a febrile soldier with intent to incise and drain the "abscess." On exposure, the mass was seen to pulsate, the correct diagnosis of pulsating hematoma of the brachial artery was made, and incision withheld.

The typical story of these patients was that of usually an infantry soldier sustaining a small puncture wound by a mortar or high-explosive shell fragment or bullet. The wound of entrance rarely lay directly over the involved vessel or vessels, usually some inches away. The path of the missile was usually oblique

and, in all cases, there was partial rather than complete severance of the vessel wall. Initial bleeding, although brisk to severe in twenty-two patients, usually subsided after several minutes. A tourniquet was used in only nine cases. A compression bandage proved sufficient in the remaining.

The soldier usually had to wait in a foxhole for the company aid man, or drag himself some distance to a battalion aid station, where sulfanilamide powder was applied locally and penicillin injections begun, to be maintained during transit. Early débridement was done, followed in seven to ten days by secondary wound suture. Days to weeks later, a pulsating mass, usually painful, developed.

The wounds were surprisingly free from infection in forty-one cases. There were two cases complicated by gas gangrene, with one death and one recovery.

CASE REPORTS

CASE 2.—On July 16, 1944, a 22-year-old infantry corporal was struck by an 88 mm. shell fragment in the left lumbar region, at the level of the second lumbar vertebra. The fragment coursed downward beneath the inguinal ligament, partially transecting the profunda femoris artery, to lodge deep in the lower third of the left thigh.

Fig. 7.—Extensive gas gangrene of the thigh in a patient with a large arterial hematoma of the profunda femoris artery. Note the deep pockets of gas. The shell fragment had entered the thigh via the left flank at the level of the second lumbar vertebra.

On arrival at the general hospital eleven days later, the patient was acutely ill. The temperature was 101° F., the pulse 114, the respirations 28. The left thigh was markedly swollen, with tender boggy induration of its entire posteromesial aspect. A rough thrill and systolic bruit were present over the femoral vessels just below the inguinal ligament. Roentgenogram revealed large pockets of gas deep in the thigh (Fig. 7). Radical incision and drainage well away from the aneurysm and under ether anesthesia were done, with removal of infected clot and gangrenous muscle, namely, the adductor group. Active hemorrhage required proximal ligation of the common femoral artery and vein. The patient went into sudden collapse and died seven hours later. Post-mortem examination revealed two pulmonary emboli (2.5 cm. and 1.0 cm. diameter) plugging the major pulmonary artery of the left lower lobe. The left femoral vein contained several nonadherent thrombi similar to those in the lungs. Cause of death was pulmonary embolism, arising from thrombophlebitis of the left femoral vein, superimposed upon extensive gas gangrene myositis of the left thigh.

CASE 3.—A 26-year-old infantry private first class developed gas gangrene myositis in the wound of exit, four days after a German rifle bullet entered just below the right antero-superior spine, partially transected the common femoral vessels, and emerged in the right mid-buttock in Nélaton's line. *Clostridium welchii* and *Clostridium sporogenes* were cultured. Radical incision, drainage, and débridement of the buttock wound were done, followed by six transfusions and uneventful recovery. The arteriovenous aneurysm showed no further complications. The Moschcowitz-Matas test showed the collateral circulation of the foot inadequate. Intermittent compression of the common femoral artery by the patient was begun. The patient was transferred to the Zone of the Interior in the sixth week for eventual operation.

Age.—Thirty-nine patients were under 30 years of age, and four were over 30. The youngest patients, six in all, were 19 years of age, the oldest was 37 years. The average age was 24 years. Experience has shown that the young patient certainly withstands ligation of major vessels with a much lower incidence of gangrene. However, the expressed attitude that "in these young patients practically any vessel in the body can be ligated with impunity" should be strongly discouraged. The real incidence of "postoperative sequelae," such as chronic circulatory deficiency with edema, claudication, and ischemic neuritis, contributes to prolonged recovery and limb morbidity.

Types of Injuries.—Jagged, small, shell fragments of from either the high velocity 88 mm., mortar, land mine, or 20 mm. type, caused the injuries in thirty-two patients. Ten were injured by the more cleanly transecting smooth rifle, pistol, or machine gun bullet. Five of the injuries were accidentally incurred while examining, cleaning, or destroying German weapons. A helmet fragment partially severed the occiptal artery in the remaining patient. The jagged shell fragment usually causes a more complicated wound. It usually lodges in the tissue, carrying pieces of clothing with it, whereas the smooth bullet is prone to perforate the limb cleanly and is less likely to carry a piece of clothing, thereby reducing the prominence of infection.

Distribution of Injuries.—In Table II is shown the location of these forty-three vascular injuries. Twenty-five aneurysms (58 per cent) involved the lower extremities, nine the upper extremities, five were within or near the thoracic cage, three the neck, and one the head. Of the twenty-nine operations, nineteen were of the lower extremities, namely, ten arterial and nine arteriovenous. Twenty of these operations were in this general hospital, eleven arterial and nine arteriovenous. Nine patients had been operated upon prior to admission here. The remaining fourteen patients were returned to the Zone of Interior with uncomplicated aneurysms, for later operation.

The indications for operation are shown in Table III. Nineteen patients had an expanding hematoma, 44 per cent of the entire series. Twelve were arterial and seven arteriovenous. Eight patients had definite ischemia for an average of thirteen days before operation. The earliest intervention was three days, the longest thirty-two days later.

Three patients had sudden severe external hemorrhage in bed, eight, nine, and ten days after injury. The blood loss was estimated at 400 c.c. in one patient and nearly 1,000 c.c. in two. Three patients had sudden interstitial rupture

TABLE II. SITES OF ANEURYSMS

	ARTERIAL		ARTERIOVENOUS	
	OPERATED	NONOPERATED	OPERATED	NONOPERATED
Head and neck				
Occipital	1			
Common carotid		1	1	1
Thoracic				
Ductus arteriosus				1
Subclavian		2		2
Upper extremity				
Axillary	2			
Brachial	4			1
Ulnar	2			
Lower extremity				
Common femoral				1
Profunda femoris	2		1	
Superficial femoral	2		3	2
Popliteal	2	1	1	1
Posterior tibial	4		4	1
Total	19	4	10	10

of the aneurysm with marked enlargement, requiring early intervention. Two patients had tense hematomas directly beneath a thin unstable scar, suggesting the possibility of rupture during further transport of the patient.

One patient arrived with a pulseless extremity and gangrene four days after sustaining a compound fracture of the femur. Immediate removal of the cast revealed a huge pulsating hematoma of the lower thigh, stretching to skin tightness beneath the cast and containing an estimated 1,000 c.c. of clotted blood. Mid-thigh amputation was unavoidable. A posterior laceration of the popliteal artery was found. The second patient developed gangrene of the lower extremity ten days after ligation of the external iliac vessels for an expanding hematoma of the femoral artery (see Operative Procedures). Operation was unavoidable in one patient with gas gangrene myositis involving the entire thigh and aneurysm of the profunda femoris artery. The outcome was fatal, as reported. Marked flexion contracture was present in three cases, namely, two of the elbow and one of the knee (see Discussion). The first patient of this series was operated upon under the mistaken diagnosis of axillary abscess, discussed

TABLE III. INDICATIONS FOR OPERATION (TWENTY-NINE CASES)

INDICATIONS	ARTERIAL GROUP	ARTERIOVENOUS GROUP
Expanding hematoma with:		
Ischemia	6	2
Pressure neuropathy	4	4
Flexion contracture	2	1
Acute rupture with external hemorrhage	1	2
Thin unstable scar overlying aneurysm	2	
Gangrene:		
Before aneurysmectomy	1	
After aneurysmectomy		1
Gas gangrene myositis	1	
"Abscess"	1	
Uncomplicated 2.5 cm. aneurysm of distal ulnar artery	1	
Total operations	19	10

previously. An uncomplicated tiny aneurysm of the ulnar artery at the wrist was removed, with early return of the patient to duty.

Associated Nerve Injuries.—Twenty-two patients, 50 per cent of the entire group, showed evidence of injury to accompanying nerves, namely, either paralysis, partial or complete, or sensory disturbances (Table IV). Operative findings repeatedly showed that neurologic examination could not disclose accurately beforehand whether the nerve injury was due to pressure of the aneurysm, with distortion, hemorrhagic infiltration, extra or intraneural fibrosis, or due to partial or complete severance of the nerve.

TABLE IV. ASSOCIATED NERVE INJURIES IN FORTY-THREE CASES

ARTERIAL ANEURYSM GROUP			
Operated (14 cases)		*Unoperated (3 cases)*	
Pressure disturbances	8 cases	Paralysis	
Ulnar	1	Partial	
Ulnar and median	1	Peroneal, sensory	1
Radial and median	1	Ulnar component of brachial plexus	1
Median	2	Complete	
Posterior tibial	2	Hypoglossal and axillary nerve to deltoid muscle	1
Posterior tibial and peroneal	1		
Severance of nerve	3 cases		
Partial			
Median, with neuroma	1		
Complete			
Ulnar	1		
Posterior tibial	1		
ARTERIOVENOUS ANEURYSM GROUP			
Operated (2 cases)		*Unoperated (6 cases)*	
Pressure disturbance		Paralysis	
Recurrent laryngeal nerve brachial plexus, sensory component of radial nerve	1	Partial	5
		Recurrent laryngeal	1
		Ulnar-sensory	2
		Sensory-inner thigh	1
Severance of nerve-partial		Posterior tibial nerve	1
Laceration of lateral cutaneous nerve of thigh	1	Complete	1
		Median	1

At operation, the nerve trunk was ecchymotic and infiltrated with blood in three patients. There was binding extraneural fibrosis in three. One traumatic neuroma arose from an incompletely severed median nerve, and one from a completely divided posterior tibial nerve. A large gap existed in a divided ulnar nerve (2.5 cm. destroyed) and a posterior tibial nerve (3 cm. destroyed). Two patients who were not operated upon had signs of incomplete division of segments of the brachial plexus.

In ten instances the following adjuvant procedures were done in conjunction with eradication of the aneurysm. Neurolysis was done in seven cases, separating by knife dissection the bound, distorted nerve trunk from the inflammatory fibrous tissue surrounding the aneurysm. The nerve was restored to its normal position following evacuation of the hematoma and removal of the aneurysm sac. The nerve was carefully palpated for areas of increased fibrous thickening. Endoneural injection of 1 to 2 c.c. of normal saline solution was then made in the hope of minimizing or preventing adhesions. Primary suture of the nerve was done in two cases, following excision of the neuroma, one median and one

posterior tibial. Eight zero silk was used, and the anastomosis was wrapped in an inverted vein segment (Fig. 8). In the third patient, who had a severed ulnar nerve with 3 cm. shot away, anastomosis was deferred because of the considerable reaction from the large expanding hematoma and adjacent fractures of the olecranon and of the lower end of the humerus. The ends of the nerve were isolated for future repair and neurolysis of the median nerve was performed.

Fig. 8.—Removal of cast three weeks after excision of an expanding hematoma of the posterior tibial artery and primary repair of the severed posterior tibial nerve. Wound of exit is seen on the outer calf.

Preparation for Operation.—Following initial studies all patients were given repeated transfusions to bring the blood hemoglobin level to 100 per cent. This provided optimal oxygen-carrying capacity to the blood coursing through impaired vascular channels, and aided in the development of collateral circulation in both the preoperative and postoperative patient. Many transfusions were often necessary due to debility arising from associated fractures, and chest, abdominal, and soft tissue injuries. The fourteen patients on whom no operations were performed were sent on to the Zone of the Interior with optimal blood levels. Instructions were given for intermittent compression of the proximal vessels by the patient himself to aid further in the development of the collateral circulation.

Testing of the collateral circulation was routinely done. With due recognition that no single test is absolute, it was felt that together with the warmth and color of the limb, the Moscheowitz-Matas test, descriptively termed by us the "blanching and pinking test," proved the most reliable in evaluating preoperatively the state of the collateral circulation.

"Elevate the extremity to an angle of 30 degrees, compress the artery with the fingers just proximal to the point of injury, and apply an Esnearch

bandage from the fingers or toes up to the point of injury. After maintaining bandage and pressure for five minutes, release the bandage while maintaining digital pressure on the artery. The limb should flush down to the fingers and toes within, at most, three minutes, preferably within one minute."[28]

If the test revealed insufficiency of the collateral circulation, further delay of operation was indicated except under most urgent conditions. Intermittent compression of the main artery was continued. Novocain interruption of the sympathetic nerves was performed for study of the possible benefit of preliminary sympathectomy.

Operative Procedures.—Cross-matching of the blood was then done and two units were made available at operation. A pneumatic tourniquet was placed but its use was kept at a minimum by the operative method employed. The affected limb was kept slightly lower than the heart, to aid in slowing the venous return. Anatomic exposure by knife dissection, first of the proximal vessels and nerves, then of their distal components, was the procedure of choice in our twenty cases. In our experience it proved vastly superior to direct approach over the aneurysm, under prolonged tourniquet control. The exposure is more generous, the procedure more orderly and under better control, with less trauma and better safeguard against possible injury to dislocated vessels and nerves. The artery, vein, and nerve were isolated in their normal relations, the vessels controlled by tape proximally and distally, thereby securing the main blood supply. Then the aneurysm sac was dissected, the clot evacuated, and the injury to the vessels and nerves visualized, despite the distortion due to widespread inflammatory fibrosis. Wherever possible, excision of the aneurysmal sac and of the injured segment of artery and corresponding segment of vein, injured or uninjured, was done. Should bleeding from the collateral vessels between the sac and the surrounding tissues become troublesome, then the tourniquet could be tightened for a shortened period. The collateral circulation was further tested at operation by the Coenen test, namely, by releasing the distal end of the divided artery and noting the briskness of retrograde flow. This aided in deciding the need for postoperative sympathetic blocks, temporary or permanent. In our twenty cases, the flow was moderate to brisk in all patients.

Exposure and control of the vessels proximal and distal to the aneurysm repeatedly proved to be the simplest part of the procedure. The remainder at times proved quite harrowing. The sac membrane, though usually dissectible, may be ill formed, thin, or densely incorporated in the surrounding structures with alternate vascular channels and no plane of cleavage. It may at times prove wiser and less damaging to leave a portion of the sac than to endanger the collaterals by persisting in attempts to remove the densely adherent portion. Quadruple ligation with excision of the fistula and damaged vascular segment will cure the fistula, whether or not the entire aneurysm sac is removed.

"Avoidance of serious loss of blood requires skill and great familiarity with the lesion."[28] No undue bleeding was encountered in the group with arterial aneurysms. In the group with arteriovenous aneurysms, even with control of the proximal and distal vessels, bleeding occurred in several patients from sur-

rounding dilated vessels and blind deep sources difficult to control. Ten patients, five with arterial and five with arteriovenous aneurysms, were given from 375 to 1,500 c.c. (one to four units) of blood at operation (Table V). All but three patients were given transfusions at operation.

TABLE V. TRANSFUSIONS GIVEN DURING OPERATION (TWENTY-NINE CASES)

NUMBER OF TRANSFUSIONS GIVEN		NUMBER OF CASES
None		3
Arterial	3	
One (375 c.c.)		16
Arterial	11	
Arteriovenous	5	
Two		5
Arterial	3	
Arteriovenous	2	
Three		4
Arterial	2	
Arteriovenous	2	
Four		1
Arteriovenous	1	
Total		29

With both arterial and arteriovenous lesions, the operative treatment was essentially the same. Quadruple ligation after excision of the damaged vascular segments, with removal of the aneurysm and foreign body, comprised the desired procedure. The vessels were transfixed with silk. Nonabsorbable sutures of cotton, silk, or nylon were used throughout, with greater reliance on silk for the vascular ligatures. A mixture of sulfanilamide (15 Gm.) and penicillin (100,000

TABLE VI. VASCULAR OPERATIONS ON TWENTY-NINE PATIENTS

	ARTERIAL ANEURYSM	ARTERIOVENOUS ANEURYSM
Ligation of proximal and distal artery, plus:		
Evacuation of hematoma	2 Axillary	None
Excision of aneurysmal sac	1 Femoral	None
Quadruple ligation:		
Alone	1 External iliac	
Plus evacuation of hematoma	11 { 1 Common femoral; 1 Profunda femoris; 1 Popliteal; 3 Posterior tibial; 3 Brachial; 1 Ulnar; 1 Occipital }	4 { 2 Femoral; 1 Popliteal; 1 Posterior tibial }
Plus excision of aneurysm	3 { 1 Brachial; 1 Ulnar; 1 Posterior tibial }	5 { 1 Common carotid artery plus jugular vein; 1 Femoral; 1 Profunda femoris; 2 Posterior tibial }
Plus endoaneurysmorrhaphy and partial excision of sac	None	1 Posterior tibial
Amputation		
Primary	1 Mid-thigh	None
Secondary	1 Mid-thigh	None

units) was sprinkled lightly in the wound. Primary closure was done in all patients, with drainage of one femoral aneurysm for doubtfully complete hemostasis.

In twenty-five patients both the artery and vein were divided and ligated (Table VI). Three patients had division of the artery alone, above and below, two axillary and one superficial femoral aneurysms. The remaining patient required mid-thigh amputation three hours after admission, for gangrene following a huge pulsating femoral hematoma, exerting pressure within the four-day old cast. Endoaneurysmorrhaphy, plus quadruple ligation, was done in one patient to control troublesome deep bleeding from collateral vessels.

Neither the gangrene-producing hunterian ligation of the proximal artery alone nor the incomplete proximal ligation of the artery and vein predisposing to persistence of the fistula was done. Arterial repair, end-to-end suture, and transvenous suture of the artery were not feasible in any of these patients because of the inflammation, extravasation of blood, and fibrosis.

Eighteen ligations involved the lower extremity, namely, one external iliac, seven femoral, two popliteal, and eight posterior tibial (Table VII). There were eight of the upper extremity, namely, two axillary, four brachial, and two ulnar. There were two of the neck, namely, one of the common carotid artery and internal jugular vein, and one of the occipital artery.

TABLE VII. VESSELS LIGATED

Head and Neck		
Occipital		1
Common carotid artery and Internal jugular vein		1
Upper Extremity		
Axillary		2
Brachial		4
Ulnar		2
Lower Extremity		
External iliac		1
Femoral		7
Common femoral	1	
Superficial femoral	4	
Profunda femoris	2	
Popliteal		3
Posterior tibial		8
Total		29

Secondary mid-thigh amputation was required for gangrene ten days after ligation of the external iliac vessels, six inches proximal to an expanding femoral hematoma of thirteen days' duration. Although the distal femoral vessels were ligated, the hematoma under tension was not evacuated. Discoloration, swelling, pain, and ischemia had been present preoperatively. The importance of proximal ligation close to the lesion, preferably just distal to an arterial tributary, and of early release of the damaging tension in the expanding hematoma is emphasized.

Ten patients had perforating wounds with no remaining foreign body. Nineteen patients had penetrating wounds, with retained shell fragments (Table VIII). In twelve the foreign bodies were removed at operation. In seven cases,

TABLE VIII. FOREIGN BODIES

	PERFORATED WOUND	PENETRATING WOUND	FOREIGN BODIES PRESENT	FOREIGN BODIES REMOVED	FOREIGN BODIES NOT REMOVED
Arterial aneurysm	7	12	12	6	6
Arteriovenous aneurysm	3	7	7	6	1
Total	10	19	19	12	7

the foreign body was not removed. No prolonged search was made if the foreign body was asymptomatic, less than 1 cm. in diameter, did not impinge on a nerve, or was not imbedded in bone.

Postoperative Treatment.—A nonconstricting bandage was generally used. A circular cast was applied in three patients with gently corrected flexion contracture and two with nerve suture, to avoid tension on the suture line. With motor nerve paralysis, that is, wrist drop and foot drop, the part was maintained in neutral position by splinting. A cradle with light, preferably to the abdomen to aid vasodilation, plus morphine, and instructions to inspect the dressing for bleeding hourly for eight hours were routine. The hemoglobin was restored to 100 per cent. This required multiple transfusions in several of the patients with arteriovenous aneurysms.

Inspection of the limb was made every few hours for the first three days. Coldness, blanching of the fingers or toes, pain, and diminished distal pulsations were treated with paravertebral sympathetic blocks daily or as often as every eight hours. Reliance was placed upon interruption of the sympathetic pathways for the release of vasospasm. Such provided a factor of safety in sustaining the vitality of the threatened limb. However, temporary block with novocain was indicated in but ten patients (Table IX). It was used preoperatively in two and postoperatively in eight patients.

TABLE IX. SYMPATHETIC INTERRUPTION

	NOVOCAIN BLOCK		SYMPATHECTOMY	
	PREOPERATIVE	POSTOPERATIVE	PREOPERATIVE	POSTOPERATIVE
Arterial Aneurysm	1	3		
Arteriovenous aneurysm	1	5	1	2
Total	2	8	1	2

The Ochsner technique was used, injecting 5 to 10 c.c. of 1 per cent novocain through each of four needles close to the first four lumbar ganglia. Injection of the first three thoracic sympathetic ganglia was done in one patient.

Lumbar sympathectomy was done in three arteriovenous patients. One was done preoperatively in preparation for ligation of the common femoral vessels (Fig. 9). The collateral circulation of the foot was inadequate by testing. The aneurysm arose from the origin of the profunda femoris vessels, and ligation of the common femoral vessels was happily avoided. One patient, despite repeated paravertebral blocks, had a recurrently cold ischemic foot four days after excision of an aneurysm of the superficial femoral artery and vein. Sympathec-

tomy was done on the fourth day with gratifying warmth of the leg and uneventful recovery (Fig. 2). In the third patient sympathectomy was done for its possible nutritive value twenty days after excision of an aneurysm of the superficial femoral artery. Muscular pains and coolness persisted despite 100

Fig. 9.—A patient three weeks after excision of an arteriovenous aneurysm of the profunda femoris vessels at their origin. Preliminary lumbar sympathectomy was done three weeks before excision, because of poor collateral circulation tests. Wound of entrance can be seen in lateral thigh. The shell fragment was removed.

per cent hemoglobin, postoperative blocks, and physiotherapy. As an adjuvant measure, this procedure seemed to help in the further improvement of the patient.

Papaverine, alcohol, and intravenous hypertonic saline solution were not used in this young age group. Early ambulation was practiced, the patient usually being allowed out of bed on the fifth day.

RESULTS

There was one death, due to pulmonary embolism at the start of an emergency operation for extensive gas gangrene of the thigh. There was loss of the limb in two patients previously described. One leg was gangrenous on arrival, due to a huge expanding hematoma of the distal third of the femoral artery exerting pressure within the cast for a fractured femur, four days after wounding. The second patient developed ischemia from an expanding femoral hematoma for which ligation of the external iliac vessels had been done. Gangrene necessitated mid-thigh amputation ten days later.

Fig. 10.

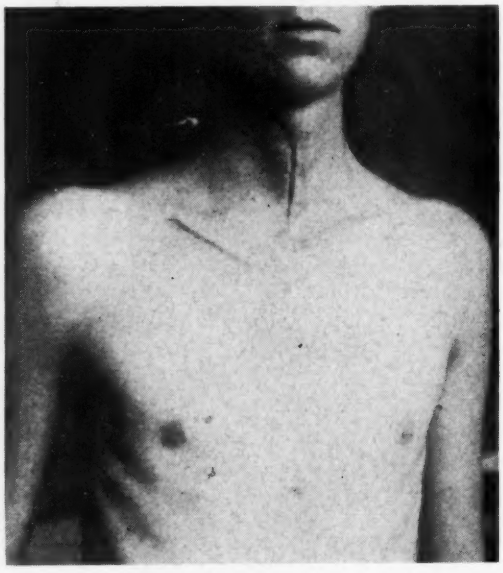

Fig. 11.

Fig. 10.—Flexion contracture and atrophy of tender right leg two months after wounding. Removal of popliteal arteriovenous aneurysm with tense hematoma and shell fragment underlying the posterior ligament of the knee was followed by uneventful recovery.

Fig. 11.—Patient (Case 4) two months after emergency quadruple ligation of the right common carotid artery and internal jugular vein. The large arteriovenous aneurysm, 18½ inches in diameter, ruptured on the ninth day after injury from a mine fragment.

The aneurysms and fistulas were successfully removed in the remaining twenty-six patients without major disturbing sequelae. Seventeen had an uneventful recovery. One patient did fairly well and one extremely well after lumbar sympathectomy for postoperative ischemia following excision of an arteriovenous aneurysm of the distal third of the femoral artery. The first patient had a congested foot and, according to a letter, six months later there was moderate swelling of the lower leg. The second patient made a functionally complete recovery (Case 1).

The remaining six patients had recoveries rated as good in three, fair in two, and slow in two. There was postoperative edema, none severe, in six patients, three following superficial femoral, one popliteal, one posterior tibial, and one axillary ligation. Five of these patients had ligation of both the artery and

vein, one the axillary artery alone. Following the latter, the swelling of the arm receded competely after one month.

Thrombophlebitis developed in two patients. In one, left femoral thrombophlebitis accompanied the extensive gas gangrene of the left thigh and it seemed the probable source of the fatal pulmonary embolus. In the second patient, the phlebitis developed fifty-six days after excision of a ruptured aneurysm of the fourth branch of the profunda femoris artery.

Flexion contracture was severe in three patients. Two had elbows fixed at 90 degree flexion due to expanding hematomas, tense, painful, and swollen for thirty and sixty-four days before intervention. These contractures were extremely difficult to correct postoperatively. The third patient (Fig. 10) had the knee fixed at 90 degrees for two and one-half months, due to a tense hematoma and a shell fragment underlying the posterior ligament of the knee, with an overlying popliteal arteriovenous aneurysm. There was gross atrophy of the thigh and calf muscles with exquisite tenderness and pain of the entire lower leg. Removal of the hematoma and shell fragment plus excision of the fistula led to prompt recovery.

Five patients complained of mild to moderate pain in the leg or foot after operation. Three had aching in the calf on walking, one had pain about the inner knee, and one had a slightly painful foot. A sixth patient complained that his foot "goes to sleep."

Of particular interest is the patient who had emergency ligation of the common carotid artery and internal jugular vein (Fig. 11).

CASE REPORT

CASE 4.—A 19-year-old infantryman, riding in a truck which ran over a mine on Omaha Beach, Normandy, France, on Sept. 16, 1944, sustained a perforating wound of the neck. The fragment entered the right neck at the thyroid cartilage, and coursed downward and backward to emerge in the right suprascapular area of the neck. Profuse bleeding was controlled by pressure bandage. Huge swelling developed, to form a pulsating mass 18½ inches in diameter. Hoarseness developed the next day. Nine days later, the anterior wound of the neck bled profusely; 2,000 c.c. of blood were given prior to operation. There was a gaping hole in the wall of the common carotid artery and a similar hole in the internal jugular vein which was separated from the artery by extensive clot. Both were ligated and transfixed with silk and the clot evacuated; 1,500 c.c. of blood were given additionally. The postoperative course was uneventful, except for frontal headache lasting ten days. There was paralysis of the right vocal cord and numbness and weakness of the right arm.

Two months later, he was still ten pounds underweight and hoarse. He had occasional headaches lasting for two days. The neck scar was well healed. The pulse was 88 and the blood pressure 108/74. The left common carotid pulse was moderately accentuated. There was atrophy of the trapezius muscle, slight weakness of the deltoid, sensory loss over distribution of the radial nerve, but no motor loss. Strength in the right arm was definitely improving.

DISCUSSION

Attention has been directed to the management of the unstable aneurysm and its complications. Four patients with arterial and ten with arteriovenous aneurysms regarded as relatively stable were returned to the Zone of Interior for later operation. There is no question that in the patient with an uncom-

plicated arteriovenous aneurysm, operation should be delayed if possible for two to four months. The shunt markedly reduces the pressure and blood flow through the distal artery. This stimulates the growth of collateral channels (Pemberton and Black[5]), and these should be given every opportunity maximally to develop. Intermittent digital compression may help further.

Arteriovenous aneurysms of smaller vessels distal to the brachial and popliteal vessels may be excised earlier where there is less danger of insufficiency of the collateral circulation.

The rationale for equally long delay in excising the arterial aneurysm is perhaps less clear. Hazardous complications, arising chiefly from expansion and rupture, are more frequent, occurring in 75 per cent of our twenty-three cases. In this lesion, the artery is usually not occluded, the distal blood flow is little altered, and collateral circulation is not stimulated to action. The full arterial force is directed into the arterial aneurysm, increasing the likelihood of interstitial or external rupture. Delay of from four to six weeks would seem desirable, however, to allow subsidence of inflammation, contamination, and infection, to allow intermittent compression of major vessels facing ligation, and to allow an orderly planned operative procedure.

Prompt recognition and treatment of acute and severe complications cannot be emphasized too strongly. Pain should not be severe. If it is unremitting and prominent, it suggests increased tension, interstitial rupture, expansion with pressure upon or infiltration of the regional nerves, and obstructing pressure upon the collateral channels. Once these have developed, the dangers of further delay can be considerable. Keeping the patient under further observation after signs of expansion were present led to serious emergency procedures, postoperative sequelae, and prolonged recovery in several of our patients.

Experiences of other surgeons in this group of hospitals attested to this danger. Kirk[29] mentioned rupture of a hematoma of the common femoral artery while under observation, with nearly fatal exsanguination. Seed[30] cites three cases of arterial hematomas in which dire complications developed while the patients were under study and preparation for operation. One patient with a hematoma of the external iliac artery died following rupture, despite ligation. The second patient had an expanding hematoma of the femoral artery in which operation was delayed, necessitating eventual amputation. The third patient (Fig. 12) had an aneurysm of the left subclavian artery at first small. It steadily enlarged to involve the entire left shoulder and axilla, and paralysis of the radial nerve developed the day before the operation.

Complications such as sensory and motor nerve disturbances, flexion contractures, and atrophy of disuse may be individually evaluated, with preference toward their early rather than late correction. Elkin and Woodhall[4] emphasized the frequency of combined vascular and nerve injuries in warfare (50 per cent in our forty-three cases). They advised planned excision of the aneurysmal sac and repair of the nerves at the same operation wherever this is possible.

No strong stand is taken for ligation of the vein accompanying a major artery. The rationale of retarding venous flow, thus allowing congestion of the

capillary bed and more complete metabolism of the available blood in the extremity, seems sound. It is felt that until the vitallium tube technique of nonsuture bridging of the arterial gap with a vein graft becomes more widely applicable, the majority of American surgeons favor quadruple ligation, that is, ligation of the accompanying vein, even though uninjured.

Attempts have been made whenever feasible to ligate the artery just distal to one of its tributaries. This avoids leaving a blind arterial diverticulum, into the walls of which the force of the arterial beat may be large, dissipated. Ligation in this manner may aid in the development of the relatively small collateral ulnar and geniculate vessels about the elbow and knee.

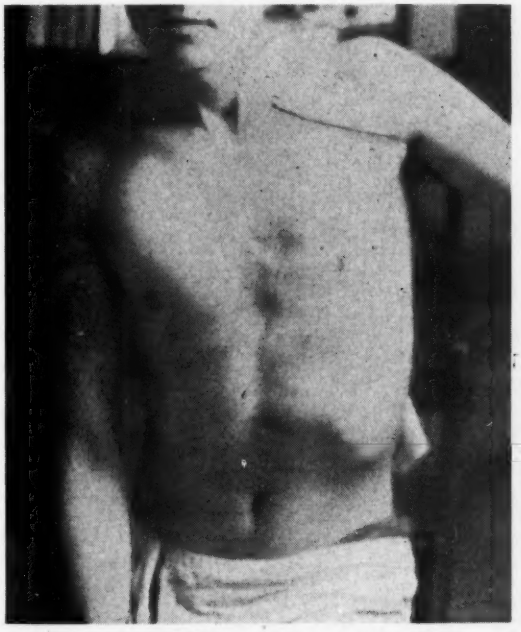

Fig. 12.—Patient fifty-one days after emergency operation for a ruptured aneurysm of the second part of the axillary artery. The clavicle had been divided for exposure. There is nonunion of the wired clavicle and abduction contracture of the left arm, as shown.

The smallest aneurysm should not be overlooked, for it may rupture and quickly cause a major complication. Opportunity to follow patients for an extended period was often provided because of necessary treatment of associated injuries, notably fractures, causing necessary delay in transport.

SUMMARY AND CONCLUSIONS

The immediate rather than late results of our experiences with relatively fresh traumatic aneurysms have been reported. The follow-up study, from one to six months, has not been sufficiently long for final evaluation of the results obtained. Hence, certain observations and statements in summary, rather than conclusions, have been suggested as follows:

1. Nine of the forty-three patients studied had been operated upon in forward hospitals; twenty were operated upon in this general hospital. Fourteen were adjudged relatively stable and safe for the overseas return trip for later operation.

2. The basic lesion of a pulsating hematoma is a partially transected vessel. The completely severed vessel usually does not give rise to a pulsating hematoma.

3. Actual or threatening complications developed in 83 per cent of the arterial and 50 per cent of the arteriovenous aneurysms. The most common were expanding hematomas, with interstitial or external rupture, hemorrhage, and damaging pressure upon both the main and collateral blood supply, and upon adjacent nerves and soft parts.

4. Prompt recognition and treatment of the acute severe complications seemed to lead to improved results. Extended delay once the complication had developed, led in some cases to a serious emergency and in general to a less satisfactory outcome.

5. The incidence of infection was 4.7 per cent, namely, two cases of gas gangrene myositis. One of these proved fatal, resulting in the 3.4 per cent mortality rate among the twenty-nine patients operated upon.

6. There was direct or indirect injury to the nerves in 50 per cent of the cases. Combined repair of the vascular and nerve injuries at the same operation under optimal conditions wherever possible has been advocated.

7. Quadruple ligation with excision of the aneurysm has been the favored procedure since 1886. It was the procedure of choice in this series.

8. Preliminary exposure of the proximal and distal artery and vein was preferred over direct incision into the aneurysm. This allowed an orderly approach, reduced the use of a tourniquet, and aided in avoiding injury to dislocated vessels and nerves.

9. Distorting inflammatory fibrosis or hemorrhagic extravasation was present in all but the very small aneurysms. This complicated the dissection and rendered difficult the use of any procedure for restoring the continuity of the vessel.

10. Loss of blood from deep collateral sources still looms as a prominent feature of the operation, especially for arteriovenous aneurysm.

11. Temporary interruption of the sympathetic nerves with paravertebral blocks, repeated as often as every eight hours, gave real vasodilating benefit, clinically. These should be used in effort to avoid sympathectomy on doubtful indications.

12. If flexion contractures due to expanding hematomas or foreign bodies in the region of joints were allowed to develop, their correction proved difficult and slow postoperatively.

13. Edema was not a serious postoperative problem. It developed in mild form in six patients.

14. The importance of maintaining the blood hemoglobin level at 100 per cent before and after operation is stressed. This aids in providing maximum oxygen-carrying capacity of the blood for the involved limb.

15. Preoperative tests of the collateral circulation were of great help, and they are regarded as an indispensable part of the preparation.

16. The advantages of delay in operating upon the uncomplicated aneurysm are clear. With the arterial aneurysm, the optimum delay would seem to be

four to six weeks. Although the collateral circulation is not stimulated, the interval will favor subsidence of infection and peripheral organization of the hematoma. With the arteriovenous aneurysm, delay of two to four months or more will aid in the maximal development of the collateral circulation.

REFERENCES

1. Holman, E.: Arteriovenous Aneurysm, Monograph, New York, 1937, The Macmillan Company.
2. Holman, E.: Immediate and Late Treatment of Arteriovenous Fistula, Australian & New Zealand J. Surg. **14**: 75-144, 1944.
3. Elkin, D. C.: Vascular Injuries of Warfare, Ann. Surg. **120**: 284-310, 1944.
4. Elkin, D. C., and Woodhall, B.: Combined Vascular and Nerve Injuries of Warfare, Ann. Surg. **119**: 411, 1944.
5. Pemberton, J. de J., and Black, B. M.: Surgical Treatment of Acquired Aneurysm and Arteriovenous Fistula of Peripheral Vessels; Review of 67 Cases, Surg., Gynec. & Obst. **77**: 462-470, 1943.
6. Bigger, I. A.: Treatment of Traumatic Aneurysms and Arteriovenous Fistulas, Arch. Surg. **49**: 170-179, 1944.
7. Maybury, B. C.: Treatment of Arterial Injuries, Brit. M. Bull. **2**: 142-144, 1944.
8. Ogilvie, W. H.: War Surgery in Africa, Brit. J. Surg. **31**: 313-324, 1944.
9. Hunter, W.: The History of an Aneurysm of the Aorta, With Some Remarks on Aneurysms in General, Medical Observation and Inquiries **1**: 323, 1757.
10. Bramann, F.: Das Arteriellvenose Aneurysma, Arch. f. klin. Chir. **33**: 1, 1886.
11. Matas, Rudolph: Some Experiences and Observations in the Treatment of Arteriovenous Aneurysms by the Intrasaccular Method of Suture (Endoaneurysmorrhaphy) With Special Reference to the Transvenous Route, Ann. Surg. **71**: 403, 1920.
12. Tuffier, M.: De l'intubation dans les plaies des grosses arteres, Bull. Acad. de méd., Paris **74**: 455-460, 1915.
13. Tuffier, M.: À propos des plaies des arteres, Bull. et mém. Soc. de chir. de Par. **43**: 1469-1471, 1917.
14. Blakemore, A. H., Lord, J. W., Jr., and Stefko, P. L.: The Severed Primary Artery in the War Wounded, SURGERY **12**: 488-508, 1942.
15. Blakemore, A. H., Lord, J. W., Jr., and Stefko, P. L.: Restoration of Blood Flow in Damaged Arteries: Further Studies on a Non-Suture Method of Blood Vessel Anastomosis, Ann. Surg. **117**: 481-497, 1943.
16. Blakemore, A. H., and Lord, J. W., Jr.: A Nonsuture Method of Blood Vessel Anastomosis, Experimental and Clinical Study, J. A. M. A. **127**: 685-690, 1945.
17. Learmonth, J. R.: Peripheral Vascular Disorders, Brit. M. Bull. **2**: 136-138, 1944.
18. White, J. C.: Progress in Surgery of the Autonomic Nervous System, 1940-1942, SURGERY **15**: 491-517, 1944.
19. Gage, M.: The Development of the Collateral Circulation in Peripheral Arterial Aneurysms by Sympathetic Block, SURGERY **7**: 792-795, 1940.
20. Veal, J. R.: The Value of Sympathetic Interruption Following Surgical Repair of Peripheral Aneurysms, M. Ann. District of Columbia **9**: 227-230, 1940.
21. Editorial: Arterial Trauma and the Sympathetic, Lancet **2**: 1944.
22. Homans, J.: Diseases of the Veins, New England J. Med. **231**: 57, 1944.
23. Schroeder, C. H.: The Radiological Demonstration of Traumatic Aneurysm, Arch. f. klin Chir. **204**: 411, 1943.
24. Gnilorybov, T. E.: One Hundred Thirty Operations on the Blood Vessels, Krirurgiya, 40-55, 1942.
25. Killian, H.: Ueber die Indikation zur Freuhoperation von Gefaessverletzungen und Aneurysmen, Arch. f. klin. Chir. **204**: 355-410, 1943.
26. Reid, M. R.: The Effect of Arteriovenous Fistula Upon the Heart and Blood Vessels, Johns Hopkins Hosp. Bull. **31**: 43, 1920.
27. Davis, Allan: Personal communication.
28. Homans, J., Allen, A. W., Elkin, D. C., De Takats, G., and Maddock, W. G.: Burns, Shock, Wound Healing and Vascular Injuries, Military Surgical Manual, 205, 209, 1943.
29. Kirk, G. D.: Personal communication.
30. Seed, L.: Personal communication.

A CASE OF COSTOCLAVICULAR COMPRESSION OF THE SUBCLAVIAN ARTERY SIMULATING ARTERIAL ANEURYSM

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CONSIDERABLE attention has been directed in recent years to a group of clinical syndromes in which certain vascular and neurologic symptoms in the upper extremity may result from structural abnormalities or may be associated with positional changes. The clinical picture associated with cervical ribs or with tendinous or cartilaginous bands extending from rudimentary cervical ribs or transverse processes, and the scalenus anticus syndrome, have become well-recognized entities. More recently, symptoms resulting from compression of the subclavian vessels and brachial plexus between the first rib and clavicle have been described,[1] as well as the relatively normal obliteration of pulsation in the arteries of the upper extremity in various positions of hyperabduction, resulting in neurovascular complaints in those who by habit or work maintain such positions for relatively long periods of time.[2] It is the purpose of this communication to describe the findings in a patient in whom compression of the subclavian artery between the clavicle and the first rib led not to any subjective complaints but presented a picture which simulated that of arterial aneurysm.

CASE REPORT

The patient was a soldier, 30 years of age, who was admitted to Mayo General Hospital on Oct. 24, 1944. Prior to Aug. 2, 1944, he had enjoyed good health and had had no vascular complaints. On this date he was wounded in France by shell fragments, receiving penetrating soft tissue wounds in the left parietal region of the scalp and in the left trapezius area. There was little bleeding. The wounds were débrided in an evacuation hospital and on August 5 he was admitted to a general hospital where an abnormal pulsation and bruit were noted in the left infraclavicular region. A diagnosis of arteriovenous aneurysm was made and the patient was transferred to the Zone of the Interior and to the Vascular Center at Mayo General Hospital.

The wounds had been secondarily sutured on August 15, with good healing. He had no complaints referable to the left upper extremity. He had noted no numbness, paralysis, or pain, and had observed no color, temperature, or sweating changes. He had noticed no dilated veins, no edema, and no trophic lesions. He thought he had noted some little swelling in the left clavicular area.

Examination revealed no visible mass or abnormal pulsation. There was, however, a strong pulsation palpable just beneath the mid-portion of the left clavicle not present on the contralateral side, and here a loud systolic bruit was heard. No thrill was palpable. He had well-developed muscles in both shoulders and arms. It was impossible to compress the subclavian artery above the clavicle nor the axillary artery beneath it, and hence tests for collateral circulation could not be carried out. There were no color changes in hands or feet. There was no thickening or tortuosity of the peripheral arteries. Radial, ulnar, and brachial

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pulses were normal and equal in the two extremities. Venous filling time was three seconds in both hands. A number of dilated veins were noted in the left pectoral and infraclavicular area. Skin temperature studies revealed no significant difference in the temperature of the fingers of the two hands. There was no edema, no abnormal sweating, no trophic or neurological changes. Kahn reaction was negative. Roentgenograms revealed several metallic fragments in the left parietal scalp, in the left side of the neck, and in the left supraclavicular area.

It was felt that the patient had an arterial aneurysm, traumatic in origin, of the distal end of the left subclavian or of the proximal end of the axillary artery. Because of the inability to test the collateral circulation and a feeling of insecurity as to its adequacy, it was thought that it would be safer to carry out a sympathectomy before exploration. On Oct. 31, 1944, a preganglionic upper dorsal sympathetic denervation was accomplished. On December 30 the vessels were explored. The entire extent of the axillary artery was visualized by dividing the insertions of the pectoralis major and minor muscles. No aneurysm was found in the axillary artery nor in any of its branches. The axillary vein was bifid and was somewhat dilated just distal to the point where it passed beneath the clavicle and where its two branches joined. The clavicle could be elevated sufficiently to permit visualization and digital exploration of the subclavian vessels beneath, and neither here nor above the clavicle was there evidence of aneurysm nor of constriction of the vessel by scar tissue. No foreign body was encountered. No bruit was audible at the close of the procedure. The muscles were resutured and the wound was closed in layers with fine black silk sutures. Convalescence was uneventful.

It was noted postoperatively that the bruit was sometimes loudly audible and sometimes absent. The prominent pulsation beneath the clavicle persisted. Finally, observations were made which it is felt offer adequate explanation for the findings. The bruit was present and intense when the patient stood with shoulders unsupported. It was absent when he lay down. When he sat with elbows resting on the arms of a chair a single short bruit was heard with each inspiration and expiration but was not audible when respiration was held either in inspiration or expiration. When he stood or sat with arms unsupported hanging by his sides the bruit ceased completely during full inspiration, and concomitantly all arterial pulsations in the left upper extremity disappeared. Downward traction upon the shoulders had no effect upon pulsation, bruit, or the radial pulse, nor did various positions of abduction or hyperabduction with the extremity in the plane of the body, forward or backward. Similarly, strong backward thrusting of the shoulders with head turned to either side had no effect upon bruit, pulsation, or radial pulse. When he attempted to elevate the left shoulder against downward traction on the arm the bruit often disappeared. Blood pressure was 128/78 in the right arm, 120/80 in the left. As shown in Table I, oscillometry was normal in the two arms except during deep inspiration with the patient sitting and arms hanging unsupported by his sides when oscillations ceased completely in the left arm. The

TABLE I. SHOWING OSCILLOMETRY IN THE TWO ARMS WITH VARIOUS POSITIONS OF THE UPPER EXTREMITIES DURING NORMAL BREATHING AND DURING DEEP INSPIRATION

	OSCILLOMETRY			
	RIGHT		LEFT	
POSITION OF EXTREMITY	NORMAL BREATHING	DURING DEEP INSPIRATION	NORMAL BREATHING	DURING DEEP INSPIRATION
Arm hanging down adducted to side	6 at 110	6 at 110	7 at 110	0
Arm hanging down, shoulder thrust backward, head turned to opposite side	6 at 110	6 at 110	5.5 at 110	0
Arm abducted 90 degrees	6 at 110	6 at 110	6 at 110	0
Arm hyperabducted over head	5 at 110	5 at 110	6 at 110	0

same occurred when the patient stood with arms hanging without support. When the patient lay down there was no change in oscillometry during forced inspiration. Venous pressures in the cephalic veins in the anticubital fossae with the patient standing varied from 48 to 60 cm. in both arms. With deep inspiration there was a rise of 5 cm. or more on the left side and a drop of about 5 cm. on the right.

The left hand remained somewhat better colored than the right in all positions. Radial and ulnar pulses were full in both wrists. In a room at 22° C. the skin temperatures of the right fingers varied from 17.5 to 20° C.; those of the left from 32.5 to 33.5° C. The left side of the face and the left upper extremity did not perspire. Ergometer studies done on several occasions revealed no essential difference in fatigability of the right and left hands. The patient had a full range of shoulder motion in the left shoulder and had no complaints referable to the upper extremities. X-rays taken in the lordotic position showed some narrowing of the space between clavicle and first rib on the left with inspiration but these findings were not conclusive.

The final impression held was that the patient's signs were due to compression of the subclavian vessels between the first rib and the clavicle. When he stood with arms unsupported there was partial compression giving a loud systolic bruit. In the recumbent position this was absent. Full inspiration in the standing or sitting position caused sufficient compression to shut off completely all flow of blood to the left upper extremity. With normal respiration this did not occur. Since the patient had no complaints and had ample circulation under ordinary conditions it was felt that operative interference was unjustified. The patient was returned to duty.

DISCUSSION

The diagnosis of arterial aneurysm is ordinarily not difficult. The three cardinal signs, a pulsating mass, systolic bruit, and systolic thrill, are often present. Not infrequently, particularly if the aneurysm is covered by heavy musculature, a definite pulsating mass is not visible or palpable but there is almost always an abnormally strong pulsation in the involved area. The thrill is often absent. The bruit varies in intensity and its intensity gives no clue as to the size of the aneurysm. Occasionally the diagnosis is difficult, especially when the aneurysm is deep to well-developed muscles. The most common conditions which may be confused with aneurysm are solid tumors which lie beneath or upon large arteries with resultant transmitted pulsation and with a bruit from partial compression, and conditions of partial constriction of arteries by scar tissue associated with at systolic bruit. Rarely scalenus anticus compression and cervical ribs may cause signs simulating aneurysm and may indeed be associated with aneurysmal dilatation of the artery.

In those instances of costoclavicular compression reported by Falconer and Weddell no signs are described which would have made one suspicious of aneurysm. In one of the four cases they described, the subclavian artery was slightly dilated proximal to the point where it passes underneath the clavicle. Because of this occurrence they suggested that the distal artery dilatation observed in certain cases of cervical rib may actually have been unassociated with cervical rib pressure but may have resulted from a coincident costoclavicular compression. In those cases of cervical rib and scalenus anticus syndrome in which there are signs suggesting aneurysm or in which arterial dilatation is noted at operation, attention to the disorder ordinarily results from the neurovascular complaints in the extremity.

In the cases of costoclavicular compression reported by Falconer and Weddell, backward and downward movement of the shoulder caused the greatest

compression of the subclavian vessels, and hyperextension of the neck did this to a lesser extent. No mention is made of the effect of respiratory movements. It is of interest that in the case I have described deep inspiration completely occluded the subclavian arterial blood flow. There was evidence of partial compression of this vessel as manifested by a systolic bruit when the patient stood or sat with his arm hanging down unsupported. Backward and downward movements of the shoulder and hyperextension of the neck seemed to have little further demonstrable effect. In cases of costoclavicular compression observed in the future with the vascular or neurologic complaints described by Falconer and Weddell it will be of interest to observe whether there is present any abnormal pulsation, systolic bruit, and whether the pulses in the arm are obliterated by deep inspiration.

The case I am reporting represents, as far as I am aware, a new type of syndrome simulating aneurysm. The patient had no complaints at all. Because of a wound which might have injured the subclavian or axillary artery and signs suggestive of aneurysm he was thought to have an asymptomatic traumatic arterial aneurysm. Prior to operation no doubt existed as to the validity of the diagnosis. Aneurysms in this area as large as lemons, have, in my experience, not infrequently been accompanied by less convincing signs, such as no pulsating mass, no thrill, less strong pulsation, and less intense bruit. So strong was the impression that the patient had an arterial aneurysm that he was subjected to two operations. No aneurysm can be explored without the definite possibility that its cure may entail ligation of the artery involved. Although the subclavian and axillary arteries can often be severed with relative impunity this is not necessarily true. I have recently seen a patient operated upon elsewhere for such an aneurysm, in whom gangrene and loss of the thumb resulted. Arterial aneurysms, in contrast to arteriovenous aneurysms, provide notoriously poor stimulus for development of collateral circulation. The efficacy of sympathectomy in improving a functionally insufficient collateral circulation is well established. For these reasons the patient was sympathectomized prior to exploration. Had the proper diagnosis been made before operation the patient might have been spared these operative procedures. It is in the hope that recognition of the syndrome described, rare though it may be, may be useful in this regard that this case is reported. The question can be raised as to whether the clinical picture was the same before and after operation. It can only be said that nothing was done at exploration which should have altered the situation and that the postoperative findings offer adequate explanation of the picture presented before operation.

SUMMARY

A case of costoclavicular compression of the subclavian artery is presented and discussed which closely simulated that of arterial aneurysm.

REFERENCES

1. Falconer, M. A., and Weddell, G.: Costoclavicular Compression of the Subclavian Artery and Vein, Lancet **245**: 539-543, 1943.
2. Wright, I. S.: The Neurovascular Syndrome Produced by Hyperabduction of the Arms, Am. Heart J. **29**: 1-19, 1945.

BATTLE CASUALTIES FROM THE PHILIPPINE ISLANDS

Summary of Experience With Four Thousand and Forty Cases

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THE surgical management of battle casualties has been divided appropriately by Churchill into initial surgery, reparative surgery, and reconstructive surgery.

This presentation is an analysis of surgical battle casualties admitted to this general hospital in Hollandia, Dutch New Guinea, from the campaign for the Philippine Islands in World War II. During a period of five months, 4,040 surgical battle casualties (wounded in action) were hospitalized. During the first six weeks of the campaign, patients were transported to this hospital via hospital ships, arriving five to ten days after injury. As the battle lines extended to the Northern Philippine Islands, the time interval between injury and admission to this hospital increased. Evacuation of patients in these latter months necessitated emergency treatment at a battalion aid station or clearing company, an ambulance ride of varying numbers of miles, treatment at an evacuation hospital, and transfer to a landing craft and to one or more hospital ships over a period of time averaging twenty-one days. Supply and evacuation lines, which in the Southwest Pacific extended over island chains and long water routes, created a military situation in which medical installations of all echelons were called upon for the ultimate in surgical care. Data presented in this analysis represent a tribute to the excellent relay management of patient care by medical units in the forward areas and by the medical and nursing staffs of hospital ships. Although many of the wounded were evacuated from the Philippines by air to general hospitals, the patients reported upon in this analysis all were transported via hospital ship. Since the campaign for the Philippine Islands was the first large scale amphibious operation in the Southwest Pacific, it afforded the opportunity to study the effects of hard learned lessons in military medical practice. To one of us who had cared for battle casualties from the jungle fighting in New Guinea, on New Britain, and on the Admiralty Islands in the earlier years of the war, it was apparent that the improved condition of the patients and of their wounds was due to several innovations in military medical methods. One of these was ready availability of whole blood at the time of beach landings. This was supplied by landing craft equipped with refrigerated blood banks. Surgical teams, the personnel of which were recruited from the best surgical specialist talent in this theater of war, functioned in the forward area, often in the front lines. The fact that surgical consultants, vested with authority to define the treatment of the casualties, assumed the role of instructors, constantly advising, consulting, and teaching, was a factor of inestimable value. Because of

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their relative adaptability to the rigors of life in a fox hole, younger medical graduates often were assigned to the medical installations in the forward areas. While these officers were suited better than older surgeons to the life under battle conditions, it was not always true that their knowledge of surgical principles and procedures was sufficient to meet the demands of early surgical care of casualties. It was the excellence of the professional activities of these young officers which rewarded the efforts of the surgical consultants during the campaign for the Philippine Islands. The wounded arrived at general hospitals in better condition than did those of earlier campaigns. A factor which contributed to this result was that the transportation of wounded soldiers by hospital ships, staffed with selected professional personnel and equipped with all necessary facilities, represented a step in continuation of treatment rather than an interruption to it. The professional personnel of the forward areas and of the hospital ships may view with satisfaction the facts that 43 per cent of patients received adequate dosages of penicillin while en route to this hospital, that 71 per cent of patients requiring surgery received their initial operative surgery within eight hours after injury, and that only forty-six patients (approximately 1 per cent) developed serous anaerobic infection or gas gangrene.

In the continuation of surgical management of casualties the reparative phase of surgery is carried out in the general hospital. With adequate facilities and personnel the opportunity is presented here to start the patient on the road to recovery. Causes of fever are determined, anemia is combated by frequent transfusions of blood, tropical diseases are diagnosed and treated, infected wounds are given wide drainage, fractures are reduced, granulating wounds are closed by secondary suture or skin grafting, complications are managed, and physical therapy is started. Thus, in the Southwest Pacific Theater of War, due to the circumstance of distance and the strategic locations of general hospitals, the reparative phase of surgery has had an opportunity for development which has been unequaled in this world conflict. It is true that as the surplus of empty hospital beds diminished, there was pressure to evacuate patients promptly to the Zone of the Interior. But the decision as to whether any patient was in condition to be transported over the long water route to the United States rested finally with the professional staff of the general hospital. Thus, it was the policy to hold major fractures until their fragments were united solidly, to close all wounds by secondary suture or skin grafting, to remove foreign bodies, to manage the late treatment of gunshot wounds of the head, to repair injuries of peripheral nerves, to treat hemothorax vigorously until full expansion of the lung was effected, to reduce complicated fractures of the jaws and facial bones, to maintain traction effectively to amputation stumps, to treat the secondary complications of peripheral vascular injury, and to initiate the first steps in the physical and mental rehabilitation of the wounded. Here again the far-reaching influence of the professional consultants of the Army Service Forces was evidenced in the accurate selection of professional personnel to fit the needs in surgery and the surgical specialties in these large general hospitals which often housed as many as 3,000 patients at one time.

Of the 4,040 surgical battle casualties which were admitted to this hospital from the campaign for the Philippine Islands, exact statistical data are available on 3,383 patients. The information in this analysis was gleaned from a personal study of the patients and their disabilities by a medical officer as they arrived at, and underwent treatment in, this general hospital. The report is arranged similar to the fashion of beside analysis. Anatomic locations of injuries are considered first. Then, in order, complications, treatment before arrival at this hospital, the time interval between injury and operative surgical treatment, the elapse of time between injury and arrival at this hospital, the condition of the patients on admission, the mortality rate, and the causes of death will be discussed.

TABLE I. WOUNDS OF SOFT TISSUE IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ANATOMIC LOCATION	NUMBER OF WOUNDS	PER CENT OF TOTAL
Scalp	105	3.3
Face and neck	222	7.0
Thoracic wall	284	9.1
Abdomen	124	3.9
Buttock	161	5.1
Shoulder	234	7.5
Upper extremity	662	21.2
Lower extremity	1,045	33.5
Multiple minor wounds	168	5.3
Burns	59	1.8
Blast symptoms	55	1.7
Total	3,119	

In Table I are listed the locations of wounds of soft tissue. The high incidence of wounds of soft tissue (71 per cent of all wounds) compared to the relatively low incidence of fractures (29 per cent of all wounds) in this war against the Japanese supports the impression that the explosive missiles (mortar shells, artillery shells, and bombs) of the enemy commonly fragment into many small particles. Not many patients were seen who were struck by very large fragments of shells. Probably in some cases larger fragments of shells were removed from patients at medical installations in the forward areas. Many reports, however, are in agreement that larger shell fragments were not encountered as often as were multiple smaller ones and that the impact of these larger missiles usually caused death. Commonly these small missiles caused great damage to soft tissues or bones although the wounds of entry and of exit were relatively small. The largest foreign body removed from the group of patients at this hospital was a fragment of hand grenade which measured 2 by 4 cm. The historical pattern of war wounds is followed in this series of cases in that the extremities were involved in 62 per cent of the cases. Forty of the fifty-nine cases of burn were flash burns sustained on the decks of Liberty ships which were crash-dived while in harbor.

It is interesting to note that wounds of soft tissue occurred almost two and one-half times as often as compound fractures. Thus, the importance of the surgery of wounds of soft tissue is emphasized. It is one of the most important aspects of reparative surgery.[1] Approximately one-third of the procedures in operative surgery in this hospital were directed toward the closure, the revision,

or the skin grafting of wounds of soft tissue. It is believed that the surgeon who emphasizes the prompt surgical repair of wounds of soft tissue will accomplish more by returning soldiers to duty and by preventing ultimate deformity than will the surgeon whose efforts are limited to the care of the more grave injuries of the osseous, vascular, nervous, or other systems.

TABLE II. FRACTURES IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ANATOMIC LOCATION	NUMBER OF CASES	PER CENT
Skull	62	4.9
Facial bones including mastoid	47	3.7
Mandible	89	7.1
Spine	29	2.3
Ribs	80	6.3
Pelvis	30	2.4
Shoulder girdle	57	4.5
Humerus	122	9.7
Forearm bones	111	8.7
Bones of wrist and hand	106	8.4
Femur	143	11.2
Patella	12	.1
Tibia and/or fibula	174	13.7
Bones of ankle and foot	123	9.7
Wounds of knee joint	47	3.7
Wounds of elbow joint	20	1.6
Total	1,272	

As shown in Table II, fractures of the femur (11.2 per cent of all fractures) are not significantly more frequent in occurrence than are fractures of the bones of the face (10.8 per cent of all fractures). Fractures of the skull, on the other hand, account for less than 5 per cent of the major fractures. This is mute evidence of the particular value of the metal helmet in the Pacific war in which the enemy up until this time has used small bullets and shells which fragment into small particles. In the Luzon campaign more heavy artillery was employed and the incidence of fractures of major bones was greater than in the earlier fighting in the Philippines.

TABLE III. AMPUTATIONS IN ANALYSIS OF 3,383 BATTLE CASUALTIES

TYPE	NUMBER OF CASES
Disarticulation, shoulder	1
Arm	18
Forearm	4
Segments of hand	36
Thigh	25
Leg	20
Segments of foot	8
Total	112

In warfare the incidence of major amputations is of prime interest. Excluding the partial amputations of the hands and feet only sixty-eight or 2 per cent of battle casualties had been subjected to major amputations. It is reasonable to conclude that all patients who survived major amputations were admitted eventually to a general hospital. There were only three cases in which the amputees had lost both limbs. One of these had lost an arm and the opposite leg; the other had lost both arms; the third had lost both legs. Forward installa-

tions regularly performed the guillotine type of amputation at the lowest possible level and traction to the skin had been applied to the amputation stumps in preparation for transportation in all but ten of the patients. As a result, at the time of arrival at this hospital, the wounds showed healthy granulation tissue with the skin of the stump drawn down over the level at which bone and muscle had been incised. In the management of these wounds of amputation stumps, it was apparent that the cicatricial effect of long-standing granulation tissue worked synergistically with external traction on the skin to reduce the open wound to a minimum in a period of four to six weeks. Contrary to the principles of surgery of simple wounds of soft tissue, there was no indication for procedures of secondary suture or skin grafting. These patients were given intensive physical therapy to the muscles of the stump and attention was directed toward the psychologic adjustment of the patient to his newly acquired deformity. Many patients who had lost an arm or hand had learned to accomplish tasks such as writing and shaving at the time of their evacuation from this hospital. Revision of amputation stumps is a responsibility of the centers for reconstructive surgery in the United States.

Included in Table IV are the injuries of all organs or structures other than skin, muscle, and bone. These made up 23 per cent of the total number of cases. Comparing Tables II and IV it is noted that forty-seven or more than two-thirds of the sixty-two patients with skull fractures had evidence of associated injury to the brain. In twenty-seven of these, intracranial abscess had developed as a result of gunshot wound. In all of these the abscess was centered about the indriven fragments of skull. Often the missle had lodged at a distant site in the brain or had made its exit from the skull. The late treatment of war

TABLE IV. VISCERAL INJURIES IN ANALYSIS OF 3,383 BATTLE CASUALTIES

ORGAN INVOLVED	NUMBER OF CASES
Brain	47
Spinal cord	40
Peripheral nerve	149
Eye (forein body, contusion, laceration)	92
Ear (symptoms of blast with perforation of tympanic membrane)	149
Pharynx	8
Thyroid	3
Lung	167
Wound of the chest and abdomen	9
Penetrating wounds of the abdomen (no injury to viscera)	30
Perforation of the stomach	5
Perforation of the small bowel	7
Perforation of the colon	26
Liver	10
Spleen	1
Kidney	10
Ureter	1
Bladder	12
Testis	5
Penis	7
Scrotum	7
Spermatic cord	1
Urethra	4
Total	790

wounds of the head will be discussed in another publication.[2] Of the twenty-one patients with paraplegia due to injury to the spinal cord, fifteen were treated by laminectomy. The operative procedure had been carried out on ten of these in hospitals in the forward areas. Neurologic examination and x-ray findings showed that laminectomy offered hope of improvement in only five patients during hospitalization here. Following operation two of these recovered completely from paralysis and in three there was definite improvement. There were 149 cases of injury to peripheral nerves. Forty-nine of these were in association with fractures. In forty-five cases neurolysis or nerve suture was performed and in twelve others reparative surgery of nerves was done at the time of operation for peripheral aneurysm. In fifty-five cases the patients were evacuated to the United States, their wounds having healed spontaneously or by secondary suture or skin grafting. There were only two patients in this entire series in whom both eyes had been enucleated. One of these patients succumbed to meningitis secondary to persistent rhinorrhea. The cases of blast were those in which the symptoms of tinnitis, headache, or vertigo were associated with objective evidence of blast injury such as perforation of the tympanic membrane. One wound of the thyroid was interesting and bears reporting. The soldier was hit in the right cheek by a .30 caliber bullet which took out the maxillary teeth and passed through the lower margin of the mandible. Then, turning butt end downward, the bullet passed down into the neck where it gave him only moderate discomfort. At operation it was found completely buried in the upper pole of the left lobe of the thyroid.

There were two cases in which wounds of the kidney presented the indication for nephrectomy. One of these was of interest in that previous operation had been performed aboard ship. Hemorrhage from a large perforating wound of the lower pole of the kidney had been controlled by packing. Secondary hemorrhage while in this hospital necessitated operative intervention. The missile had destroyed the central substance of the lower pole. In addition, there was a vertical fracture of the upper pole so that nephrectomy rather than heminephrectomy was necessary. Another case of injury to the urologic tract is of interest. This patient had been wounded by a .25 caliber rifle bullet which entered the left buttock. While voiding, the patient noted that the stream of urine suddenly stopped. He was able to palpate an object in the perineal region and succeeded in voiding the .25 caliber bullet. Orchidectomy was necessary in four of the five cases of injury to the testicle. Wounds of the penis were minor in three cases, while in one case extensive deformity had been caused by cicatricial replacement of the corpus spongiosum. Reparative surgery by means of plastic flaps was successful in all cases.

Table V gives a fair insight into the operation of a surgical service in a general hospital in the Communications Zone. In 341 cases there were major complications as listed here. Minor complications of wounds and the problems associated with intercurrent tropical diseases are not included. Analysis of the cases of infection and gangrene due to *Clostridium welchii* will be set forth in

TABLE V. COMPLICATIONS IN ANALYSIS OF 3,383 BATTLE CASUALTIES

LOCATION		NUMBER OF CASES
Brain abscess		15
Epidural abscess		10
Fungus cerebri		3
Pneumocephalus		1
Rhinorrhea		2
Paralysis due to cerebral injury		25
Paralysis due to injury to spinal cord		21
Hemothorax		79
Hemothorax (fibrinous)		7
Pneumothorax		6
Tension pneumothorax		1
Empyema		49
Bronchopleural fistula		3
Subphrenic abscess		5
Paralysis of recurrent laryngeal nerve		5
Peritonitis		1
Fecal fistula (colostomy)		14
Fecal fistula (rectum and buttock)		8
Urinary fistula		13
Bladder	7	
Ureter	2	
Urethra	4	
Infections and gangrene due to Clostridium welchii		31
Pyroarthrosis of knee		14
Volkmann's contracture		1
Vascular complications		27
False aneurysms	6	
Pulsating hematoma	4	
Arteriovenous fistulas	10	
Laceration of artery-peripheral circulatory gangrene	4	
Aneurysmal varix (common iliac vessels)	1	
Secondary hemorrhage from arterial tear	2	
Total		341

detail in a subsequent communication.[3] It is interesting to note that this complication occurred in only 1.1 per cent of all cases and in 3.6 per cent of the 1,272 cases of fracture.

Intrathoracic complications occurred in 144 or 80.6 per cent of the 167 cases in which the missile had transversed the lung or mediastinum. In seventy-nine cases the complication of hemothorax was handled competently by frequent thoracentesis during the early weeks after injury. Fibrinous hemothorax developed in only seven cases. Pneumothorax was present in only three patients and these were cured by repeated aspiration. In one case tension pneumothorax was managed successfully by aspiration without resorting to water-seal or flutter-valve decompression. Analysis of the forty-nine cases in which empyema had developed is of interest. None of these patients were admitted to this hospital until the fourth to the seventh week following injury. In the early days after injury these patients were transferred to several hospitals and three ships, and thoracentesis had not been done regularly. Roentgenograms showed complete collapse of the lung and aspiration yielded thick pus. The fact that in the majority of cases the causative organism was not recovered on culture was attributed to the intrathoracic injection of penicillin. Sixteen of these patients responded to repeated aspiration and injection of penicillin.

Sixteen were treated by closed aspiration drainage and seventeen by thoracotomy. The late treatment of cerebral complications due to gunshot wounds of the head[2] and also the management of pulsating hematoma, false aneurysm, and arteriovenous fistula[4] will be reported upon in detail in subsequent communications.

After consideration of the types of injury and their complications, interest centered in the treatment before arrival at this hospital. As is shown in Tables VI and VII, an amazingly high percentage of casualties received the benefit of therapy with penicillin or sulfonamide drugs or both. The condition of these patients on arrival and the records of their treatment in the forward areas reflect the greatest credit on the work of the forward echelons of the Medical Department of the Army.

TABLE VI. TREATMENT BEFORE ARRIVAL AT GENERAL HOSPITAL IN ANALYSIS OF 3,383 BATTLE CASUALTIES

PATIENT RECEIVED	NUMBER OF PATIENTS	PER CENT
Adequate sulfonamides	2,849	84.0
Penicillin	1,479	43.0
Gas gangrene antitoxin	174	.5
Operative surgical treatment	2,502	73.6

Seventy-three per cent of all patients had required operative surgery. Sulfanilamide and penicillin had been started at the time of first surgical treatment and had been continued until the patients were admitted to this hospital or until the clinical course indicated its discontinuance. Undoubtedly this vigorous therapy as an adjunct to surgery was rewarded by a lowered mortality rate. However, it was the united opinion of surgeons who treated these war wounds that the intramuscular injection of penicillin did not in itself produce healthy granulation tissue. Wounds of patients who had been treated with penicillin showed no outstanding difference from those in patients not so treated. The health of the wound was a direct reflection of the adequacy of the local surgical treatment. The conclusion follows that surface infection of wounds still is a problem for treatment by débridement and surgical dressings. None of the wounds had been treated locally with penicillin prior to arrival at this hospital. The low number of cases in which gas gangrene antitoxin was used is an indication of the lack of confidence exhibited by surgeons generally in the use of this agent. In the clinical management of cases of infection or gangrene due to *Cl. welchii* there was no convincing evidence that the antitoxin is of value.

TABLE VII. TIME INTERVAL BETWEEN INJURY AND OPERATIVE SURGICAL TREATMENT IN ANALYSIS OF 3,383 BATTLE CASUALTIES

TIME OPERATED UPON	NUMBER OF CASES	PER CENT
Under 8 hours	1,781	71.1
Under 12 hours	245	9.7
Under 24 hours	268	10.7
Under 48 hours	141	5.6
Over 48 hours	67	2.6
Total	2,502	

Moreover, it was found that penicillin was not of value in combating the toxemia or the sepsis in such cases. These points will be discussed in a separate publication.[3]

Attention is called to the great difficulty experienced in evacuating the wounded at night because of the Japanese night infiltration tactics. Despite the difficulties of amphibious operations and the problems in jungle fighting, 71 per cent of those patients requiring operative surgery were operated upon under eight hours. This efficiency in evacuation of wounded and in the availability of equipment and personnel for the early treatment of casualties in the forward areas will go down in the history of the Army Medical Corps as one of its glorious achievements. The necessity for the performance of débridement in that golden period before a contaminated wound is converted into an infected one was demonstrated in World War I. In this conflict the patients also had the advantage of oral sulfonamide therapy from the time of injury until the time of operation.

Of interest also is the time interval between injury and arrival at this general hospital. As previously stated, the casualties included in this analysis arrived fairly soon after injury during the first six weeks of the period reported upon. During this time the fighting was on Leyte and Samar Islands and 1,112 or 33 per cent of the group of 3,383 casualties arrived on the fifth to the tenth day after injury. The remainder arrived from eleven to fifty-five days after injury as the battles took place in Luzon and related islands in the northern Philippines.

After determination of what had happened to these patients in the forward areas, interest centered on their condition on admission to this hospital. Of the 3,383 patients, 219 were critically ill. Two patients were moribund on arrival and both died shortly after admission. Three hundred ten patients had fever with elevation of temperature over 101° F. Plaster casts in 318, approximately 25 per cent of the fracture cases, were malodorous, stained, or broken. Two hundred forty-four or 7 per cent of all cases had secondary anemia, the red blood cell count being 3,000,000, or lower. Excluding fractures of the mandible which will be discussed in detail in another publication, there were sixty-three cases in which the fracture had been immobilized improperly. These made up 5 per cent of the fracture cases. "Tobruk" splints had been applied in ten cases. All of these showed severe edema of the ankle. Two developed anaerobic cellulitis. Velpeau bandages reinforced with plaster had caused pressure necrosis over the dorsum of the hand or forearm in three cases of fracture of the humerus. Apparently this type of dressing was favored by some medical officers who were conscious of the difficulties of transporting patients wearing abduction shoulder spicas.

There were nine deaths in this series of 4,040 consecutive battle casualties. This fixes the case mortality rate at ⅕ of 1 per cent. The condition of the patients at the time of embarkation for the United States from this post was such that it is unlikely that any of them failed to survive. The causes of death are as follows: meningitis secondary to cerebral abscess, two cases; gas gangrene,

three cases; peritonitis and gangrene of abdominal wall, one case; pulmonary embolus arising from femoral arteriovenous fistula, one case; hemorrhage from aneurysmal varix of the common iliac veins, one case; purulent pericarditis and septicemia following drainage of subphrenic abscess, one case.

SUMMARY

Report is made on experiences with 4,040 surgical battle casualties from the campaign for the Philippine Islands. Detailed analysis of 3,383 of these cases is presented. These were patients who were admitted to a general hospital in Dutch New Guinea. Data are presented concerning the types of injury, the complications, the treatment given in the forward areas, the time interval between injury and operative treatment, the elapse of time between injury and admission to this hospital, the condition of the patients on arrival, the mortality rate, and the causes of deaths. Wounds of soft tissue occurred two and one-half times as frequently as did major fractures. The majority of wounds were caused by small caliber bullets or small fragments of shells or bombs. Minor wounds of entry and exit commonly marked the site of extensive damage to underlying soft tissues and bone. Major amputations had been performed in only 2 per cent of cases. Eighty-four per cent of patients had received sulfonamide therapy from the time of injury until admission to this hospital. Forty-three per cent of patients had received intramuscular penicillin in adequate clinical dosage while en route to this base. Undoubtedly the fact that this high percentage of the wounded were treated by sulfonamide drugs or penicillin as an adjunct to surgery has been reflected in the saving of many lives. Close observation of wounds has provided no evidence that such therapy has resulted in less extensive infection of serious wounds. Cases of hemothorax which had been treated by thoracentesis at regular intervals did not develop complications whereas those which had not been so treated were complicated further by the development of fibrinous hemothorax or empyema. Infections or gangrene due to *Cl. welchii* occurred in 1.1 per cent of all cases and in 3.6 per cent of all fractures. Thirteen of these battle casualties died in this hospital. The case mortality rate at this station therefore is ⅓ of 1 per cent.

The introduction of certain military medical methods in this theater has resulted in improved condition of patients and of their wounds on arrival at a general hospital. Innovations in military medical practice during this campaign included availability of whole blood in the forward areas, the assignment to the forward areas of surgical teams comprising the best available professional talent, and the organized efforts of the surgical consultants who advised, demonstrated, and taught in the forward areas. The distances involved in the Southwest Pacific during the campaign for the Philippine Islands necessitated a relatively prolonged period for the patients on the hospital ships. Many patients were evacuated to general hospitals by air but this hospital received only those patients who were brought by ship. The strategic location of general hospitals at points far distant from the United States during this campaign afforded an unequaled opportunity for the application of the principles of reparative surgery.

This analysis of battle casualties reflects the greatest credit upon the work of the medical installations in the forward areas for, in the campaign for the Philippine Islands, emphasis was placed on getting the surgeon to the patient as well as upon the prompt evacuation of the wounded.

The subjects of aneurysm, gunshot wounds of the head, infections and gangrene due to *Cl. welchii*, secondary suture, and skin grafting will be presented in subsequent publications which are in preparation at this time.[1-4]

REFERENCES

1. Conway, Herbert, and Coldwater, Kenneth B.: Principles in Reparative Plastic Surgery, SURGERY **19**: 437, 1946.
2. Conway, Herbert, and Hendricks, Robert T.: The Late Definitive Treatment of Gunshot Wounds of the Head, SURGERY. (In press.)
3. Conway, Herbert: Anaerobic Infection and Gangrene of War Wounds in Casualties From the Philippine Islands, SURGERY **19**: 553, 1946.
4. Conway, Herbert, and Plain, George: Pulsating Hematoma, False Aneurysm, and Arteriovenous Fistula Due to War Injuries, SURGERY **19**: 383, 1946.

AIR BLAST EFFECT IN A CAVE

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IT IS not definitely known how effective a role air blast plays in the neutralization of enemy cave emplacements when relatively small charges of high explosives are used. Although death of personnel in caves usually results from the primary air blast it is not possible to relate the charge to its effectiveness since data on the blast effects of explosives detonated in closed spaces are not available. Bernal[1] stated that bombs exploding within buildings would produce blast effects greater than those in the open because of reflectance of shock waves from the walls, thereby producing a "prolonged pressure." The present study was undertaken to make some measurements on the degree of amplification of blast effect occurring in a cave and to delineate the effective radius of the blast resulting from a typical small charge of high explosive.

The sudden death which is unaccompanied by external injury, and yet resulting from trauma induced by high explosives, has excited interest for many years. This effect was popularly expressed in the early nineteenth century as due to "the wind of the shot" and a death presumably resulting from this was reported by McTernan in 1812.[9] However, serious attempts at elucidation of the pathogenesis and pathology of blast injury did not come until during World War I. Nothing specific in the pathologic picture had been shown until Carver and Dinsley,[3] Mairet and Durante,[8] and Hooker[5] reported the presence of pulmonary lesions in experimental animals. Current experience indicates that gross damage of the lungs occurs in both experimental and clinical blast injury. Pulmonary lesions are of indisputable importance in the blast syndrome, but Stewart and associates[11] felt that more subtle injury to the central nervous system is actually responsible for the fatalities.

Blast is simply a very intense sound wave set in motion by the detonation of an explosive.[1, 4, 12] It is composed essentially of a positive and a negative phase. The positive wave consists of a rapidly traveling shell of compressed air which acts in all directions by hydrostatic pressure. Although the initial pressure may be thousands of pounds per square inch, the pressure falls off rapidly with the square of the distance. The negative wave which is the relative vacuum existing behind the positive pressure shell cannot exceed 15 pounds per square inch. It is of importance to note that blast waves can be reflected from surfaces. Accordingly, individuals within enclosures are provided protection from explosions occurring in the open.[10]

It is generally assumed that the high positive pressure waves produce the blast injury by a purely mechanical traumatic effect but there has been con-

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siderable discussion as to the possible effects of the negative phase. Zuckerman[14] has shown that various animals subjected to the compression phase alone exhibited the pathologic changes found in patients suffering from blast. Latner[7] has produced similar lesions in mice exposed momentarily to low pressure. The use of animals of this size limits the application of his results since sensitivity to blast varies inversely with weight of the animal. Additional evidence on the cause of typical blast effects has appeared in general reviews on the subject of blast.[6, 14]

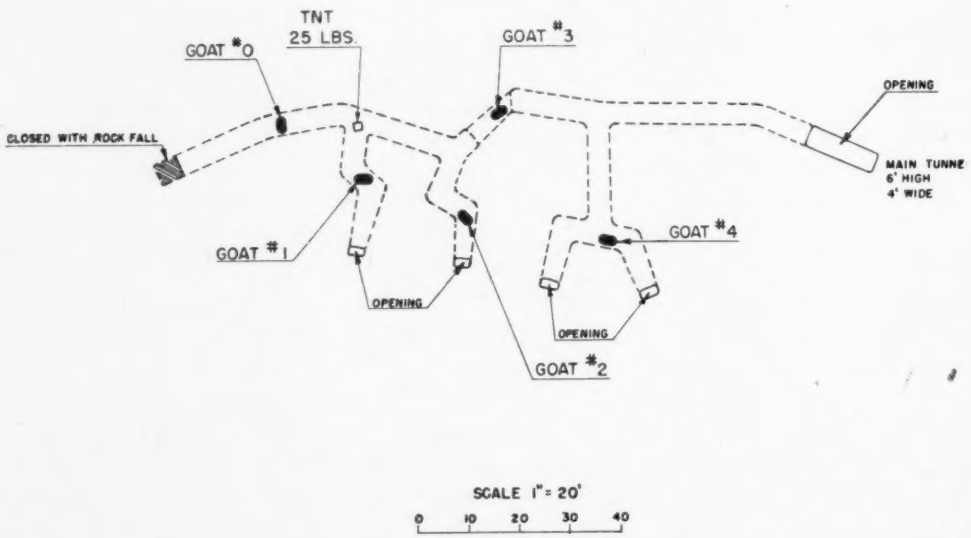

Fig. 1.—Spatial relationship of goats and explosive. Outline of cave is superimposed on the positions occupied by the goats.

The syndrome of air blast injury has been clearly described. Depending upon the size and effectiveness of the charge in relation to the protection afforded by distance and shielding, the extent of the injury may vary from undetectable changes to death itself. Cyanosis and dyspnea frequently occur as indications of lung injury. There may be coughing and chest pain, sometimes accompanied by hemoptysis. Although physical examination of the chest at first may reveal but little, the radiologic picture usually shows mottling due to pulmonary hemorrhage. However, physical signs of consolidation and/or pleural effusion may become evident the next day. Injury to the ears is common.[2] Tinnitus, deafness, pain, hemotympanum, or perforation of the drum may occur.

Pathologically[14] the most striking and consistent findings are localized in the lungs. Grossly, the lungs present hemorrhages of various shapes and sizes. Linear hemorrhages are found along the rib lines. Emphysema, atelectasis, and lacerations may also be present. Microscopically, the lungs show alveolar hemorrhage, emphysema, and edema. Any of the other tissues of the body may be sites for hemorrhages. Rupture of organs, such as the liver, is found occasionally.

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Fig. 2.

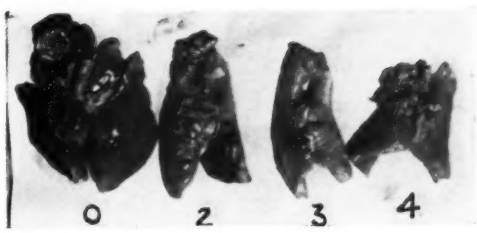

Fig. 3.

Fig. 4.

Fig. 2.—Lungs of Goat 1_c. Incisions made at autopsy indicate extensiveness of pulmonary hemorrhage in lethal blast injury. Note emphysematous right apex.

Fig. 3.—Appearance of lungs of animals exposed to blast in cave. Lungs of Goat 1_c not shown here (see Fig. 2).

Fig. 4.—Appearance of lungs of animals exposed to blast in open. Compare with Figs. 2 and 3.

METHOD AND RESULTS

Since physical methods of measurement may be subject to considerable error, animals were employed as biologic indices of blast. Five goats (60 to 80 pounds), staked in a rock tunnel, were exposed to the detonation of twenty-five pounds of paper-encased trinitrotoluene (T.N.T.) which had been placed on the cave floor (Fig. 1). An additional five goats and twenty-five pounds of T.N.T. were placed in a flat open area in positions identical with those in Fig. 1, and the explosive was detonated. All the animals were examined immediately after the explosions. The cave explosion killed two goats instantly. None of the goats in the open was killed. Exactly three hours later all live goats were killed by an intracardiac injection of magnesium sulfate and were then autopsied. Each animal was carefully examined for evidence of external injury. The thoracic and abdominal viscera were inspected grossly. The lungs with some intrathoracic trachea were weighed to the nearest quarter pound. Sections were made of the lungs. A summary of the positive findings in each goat is presented in Table I. The injured lungs are shown in Figs. 2, 3, and 4. The microscopic pattern invariably consisted of hemorrhage, edema, emphysema, and tearing of the alveoli. In Goats O_c and 1_c, the hemorrhagic aspect overshadowed the other findings. The sections revealed the tissues to be entirely filled with blood. In view of the similarity of this picture in all injured lung areas, individual findings have not been included in Table I.

DISCUSSION

The results are a demonstration that the blast effect of explosives detonated in small enclosed spaces is far greater than in the open. Two of the goats in the cave were killed and a third suffered moderate blast injury. On the other hand, none of the goats in the open was killed and only one suffered moderate blast injury. The heightened blast pressure in the cave is also indicated by the fact that two goats in the cave were hurled ten to twelve feet while none of the goats in the open were even torn loose from their stakes. The potentiation of the blast wave, probably due to reflection, is greatest in the immediate vicinity of the blast. The presence of sharp turns in the cave acted as baffles and prevented maintenance of the full magnitude of the reflected wave throughout the cave, since Goats 3_c and 4_c suffered only slight, or no, injury.

Pulmonary damage, as the most constant finding in animals subjected to blast, was used as a yardstick in determining effectiveness of charge. Since the majority of these lesions was found to extend in from the surface of the lungs (Fig. 2), the external appearance served as a rough indication of the degree of blast injury. Therefore, the potentiation of effect within caves can be shown by comparing Figs. 3 and 4. The lungs from Goat 1_c were not included in the group photograph of the cave animals as they were used to illustrate the depth to which the hemorrhages extended into the lung tissue (Fig. 2).

The blast-injured lungs showed hemorrhage, edema, and emphysema. The increase in the weights of the lungs from one to three pounds (Table I) reflects the degree of edema and hemorrhage present. In the fatal cases, additional interesting findings included hemoperitoneum, diaphragmatic hemorrhage, lacerations

of the liver, tears in the wall of the stomach, massive mediastinal emphysema, and emphysematous bullae in the pericardium. Microscopically the lungs revealed hemorrhage, edema, emphysema, and tearing of the alveoli. The occur-

TABLE I. SUMMARY OF POSITIVE AUTOPSY FINDINGS ON GOATS EXPOSED TO DETONATION OF TWENTY-FIVE POUNDS OF T.N.T.

GOAT NUMBER*	AIR BLAST DISTANCE†	EXTERNAL APPEARANCE	THORAX	ABDOMEN	AIR BLAST EFFECT
			A. Goats in Cave		
0_c	16	Dead, thrown 12 ft., horns broken, bloody froth in mouth and nostrils, conjunctival hemorrhage	Clot (100 c.c.) in right pleural space; mediastinal emphysema; extrapleural linear hemorrhages; eight air blebs in pericardium; trachea and bronchi filled with pink froth. Lungs, 3 pounds, massive hemorrhage throughout; subpleural bullae	Clot (100 c.c.) in peritoneal cavity; hemorrhages in diaphragm; liver, three lacerations; duodenum, subserosal hematoma	Lethal
1_c	11	Dead, wedged in opening 10 ft. away	Clots, bloody froth and submucosal hemorrhages in trachea and bronchi; lungs, 2½ pounds, massive hemorrhage throughout	Gastric contents in peritoneal cavity; hemorrhages and two tears in wall of stomach	Lethal
2_c	35	Dazed, dyspneic	Numerous submucosal hemorrhages in trachea and bronchi; lungs, 1½ pounds, six hemorrhagic rib markings on right lung	Petechial hemorrhages on liver surface	Moderate
3_c	33		Lungs, 1 pound, solitary hemorrhage in each lung		Slight
4_c	78		Lungs, 1 pound, several small hemorrhages in each lung		Slight
			B. Goats in Open		
0_o	16	Dazed	Bloody froth in trachea and bronchi. Lungs, 1½ pounds, large hemorrhage (9 by 3 cm.) in right lung; many small hemorrhages on lateral surface of left lung		Moderate
1_o	11		Lungs, 1½ pounds, emhysema of right upper lobe; several small hemorrhages and areas of emphysema in left lung		Slight
2_o	29		Lungs, 1 pound, six small hemorrhagic areas on right and left lung		Slight
3_o	29		Lungs, 1½ pounds, several small linear hemorrhages in right lung; internal hemorrhage in left lower lobe		Slight
4_o	55		Lungs, 1 pound		None

*Goat in cave and its control in identical position in open (Fig. 1) have same number, being differentiated by subscript c or o.

†Refers to tunnel distances for cave goats and to straight line distances for goats in open.

rence of air in the mediastinum and the pericardium (Goat 0_c) has not been previously reported in experimental animals subjected to high explosives. Theoretically, emphysema of the mediastinum might be expected to occur frequently as air from the ruptured alveoli should migrate through the pulmonic interstices. Its presence there would interfere with pulmonic and cardiac circulation producing chest pain and dyspnea.

The preponderance of pathologic findings in goats in the cave indicated the increased effectiveness of high explosive when detonated in a closed space. In extending these data to man it must be emphasized that the results would be qualitatively the same. However, quantitatively, the effect would be less, since man, due to his greater weight, is much less sensitive than the goat to blast pressure waves.

SUMMARY

Goats in a cave and in the open were exposed in identical positions to the detonation of twenty-five pounds of T.N.T. The results indicated that the blast effect of high explosives in closed spaces exceeds that in the open.

We wish to express our appreciation to Mr. H. Coopmans for the color photography.

REFERENCES

1. Bernal, J. D.: Nature, London **147**: 594, 1941.
2. Barrow, D. W., and Rhoads, H. T.: J. A. M. A. **125**: 900, 1944.
3. Carver, A., and Dinsley, A.: Brain **42**: 113, 1919.
4. Finch, G. I.: Nature, London **147**: 501, 1941.
5. Hooker, D. R.: Am. J. Physiol. **67**: 219, 1924.
6. King, J. D., and Curtis, G. M.: Surg., Gynec. & Obst. **74**: 53, 1942.
7. Latner, A. L.: Lancet **2**: 303, 1942.
8. Mairet, A., and Durante, G.: Rev. neurol. **35**: 97, 1919.
9. McTernan, J.: Lancet **1**: 385, 1943.
10. Sectional Steel Shelters: Report Upon Investigations of the Standard of Protection Afforded, Sessional Papers of The House of Commons, vol. 9, 1939.
11. Stewart, O. W., Russel, C. K., and Cone, W. V.: Lancet **1**: 172, 1941.
12. Sutherland, G. A.: Lancet **2**: 641, 1940.
13. Tunbridge, R. E, and Wilson, J. V: Quart. J. Med. **12**: 169, 1943.
14. Zuckerman, S.: Proc. Roy. Soc. Med. **34**: 171, 1941.

CLINICAL MANIFESTATIONS OF LOCAL SHOCK AND THE TREATMENT

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DEFINITION

LOCAL shock is a clinical sequence of pathologic changes exhibited after severe injuries (particularly crushing) of the extremities, characterized by local traumatic vasospasm which may extend to involve a considerable part of the extremity. Acting first as a safety reflex to stop hemorrhage and additional trauma, later it may result in capillary dilatation, incompetency, or decompensation, thereby (1) preventing normal tissue metabolism (anoxia), (2) interfering with the normal interchange of tissue fluids in the region of injury with loss of plasma, (3) piling up the products of trauma (blood plasma, shredded soft tissue, fractured bone, etc.) with no effort being displayed toward their evacuation, (4) ending often in degeneration and local death of the tissue before circulatory integrity can be re-established.

The phenomenon of local shock is terminated by (1) "Nature's kindly hand" through the release of the vasospasm and the re-establishment of capillary function and equilibrium; (2) local and general measures to stimulate return of circulation adequate splinting and elevation of the extremity; cold locally, heat generally; and other recognized restorative measures used in the treatment of general shock; (3) sympathetic novocain block; (4) sympathectomy.

SEQUENCE OF APPEARANCE OF OBJECTIVE SYMPTOMS OF LOCAL SHOCK

Assuming that there has been a severe crushing injury of the leg below the knee, involving soft tissue and bone with or without compounding, there are the following changes:

1. Almost at once at the site of crush a local area of blanching or decoloration; a cadaverish appearance with a rather distinct line of demarcation with normal peripheral color.

2. An almost immediate retraction of the skin area involved by the decoloration.

3. Local lividity and coldness of the area.

4. Gradual extension of the decoloration, retraction and coldness above and below the site of injury (particularly descending). Hours may elapse during this progress. Later there is discoloration due to extravasation of free blood and traumatic debris in the tissues.

5. Boggy swelling which often takes place due to continued vasospasm, capillary decompensation, anoxia, lack of normal tissue metabolism, interchange of tissue fluids and unabsorbed filling up of the products of trauma, which if not relieved results in tissue death and gangrene.

Local shock is to the extremity (leg or arm) what general shock is to the total human organism. It is a potential forerunner of general shock. Given the foregoing hypothetical circumstances, in which there is local vasoconstriction

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with an extending process, a falling blood pressure may well follow with increasing lack of oxygen and permanent tissue damage, thereby aggravating dilatation and permeability of the capillaries and the escape of plasma into the tissues to the extent that the entire circulatory equilibrium is upset. General shock will take place when this pathologic phenomenon progresses sufficiently.

Various terms have been applied to similar relatively synonomous pathologic phenomena as[1-7] arterial stupor, arterial confusion, arterial spasm, traumatic segmentary inhibition of the arteries, traumatic vasospasm, and Zudach's syndrome. However, it seems appropriate and less confusing to classify this phenomenon, which is so typical in extremity injuries, as local shock in contrast to general traumatic shock. Both of these types of shock may be aggravated by laceration, contusion, or concussion of the vessels in the region of injury and respond to a sympathetic nerve reflex.

It has long been recognized that a shell fragment may damage tissue near an artery and cause segmental spasm. Injuries near the knee joint (bumper fractures[8]) or humeral supracondylar fractures (Volkmann's) are prone to exhibit arterial spasm.[9, 10] We have seen the phenomenon also in fracture dislocations of the shoulder and simple fractures of the midshaft of the radius and ulna, due to being struck by a tire rim when a newly repaired tire exploded while being filled with air. In a few instances of simple and compound fractures below the knee due to kicks, falls, and crushing by farm and other machinery, we have been able to demonstrate vasospasm or its sequela surgically without gross evidence of vessel injury. The following case is a very striking example.

CASE REPORT

CASE 44-348.—A 56-year-old farmer, Mr. R. H., in the spring of 1944, was forced to crank the motor on his truck. The truck chanced to be in gear and he was shoved violently against the end of the garage, resulting in a simple mildly oblique fracture of the upper end of the right tibia with very minor displacement. He was taken by car a matter of about ten miles to his physician, a very conscientious and observing practitioner who, after x-ray examination (Fig. 1) decided that the position of the fragments was sufficiently satisfactory to justify merely applying well-padded plaster splints from the toes to the groin with the knee flexed about fifteen degrees. At the time the cast was applied he noted that there was no contusion of the skin, bruising, or even swelling despite the fact that it had been a matter of hours since the injury. For that reason he split and spread the splint the full length immediately after application in anticipation of any constriction. The toes felt cold and the extremity lacked normal color but the weather was cold and the patient had experienced considerable exposure. After hours of observation, stimulation, and general warming up, the patient felt fine and insisted upon returning to his farm. The doctor called on him the following day and noted that the decoloration of the toes and the coldness had increased but there was no swelling. Later, in consultation by telephone he was advised that from the description of the case he was dealing with a local shock phenomenon, and that an immediate lumbar sympathetic novocain block would be in order. Rain made the roads impassable and before the patient could be prevailed upon to be moved almost two weeks had passed and the toes were distinctly gangrenous. Once in the hospital, examination revealed no dorsalis pedis or posterior tibial pulsation. The toes were dry and gangrenous. The plantar, Achilles, and medial dorsum surfaces of the foot were black. There was an area on the anterolateral mid-portion of the leg that was gangrenous. The upper calf was soft and boggy and slightly swollen (Fig. 2). The rest of the leg was decolored

and cadaverish. The temperature (thermocouple) of the anterior lower leg was seven degrees lower than that of the opposite leg. Of course, this was a case for amputation. That evening, to justify the opinion that these findings were the result of persistent vasospasm and constituted the sequelae of local shock, a lumbar sympathetic novocain block of the second to the fifth lumbar vertebrae was performed and within five minutes the temperature was raised 5 degrees, or within 2 degrees of the opposite leg. A distinctly normal color came to the living integument, and in the morning before amputation the temperature was within 2½ degrees of that of the left leg. However, the site of the fracture and the extensive muscle and skin gangrene warranted supracondylar amputation. The patient made an uneventful recovery and returned to his farm work with prosthesis.

Fig. 1 (Case 44-348).—X-ray views of simple oblique fracture of upper tibia (bumper fracture) with but slight displacement.

Fig. 2 (Case 44-348).—Amputation specimen after examination by pathologist. Note the gangrenous foot and upper tibial region, also no evidence of swelling except in upper calf.

A careful dissection and examination of the specimen was made by a pathologist, who found absolutely no evidence of injury to the popliteal artery or its branches. A small adherent clot was found in the anterior tibial artery just below the bifurcation which in no wise obliterated the lumen. There was no microscopic evidence of injury in sections of the vessels. The venous system seemed to be intact. There was extensive degenerative change in the large muscles of the calf.

Here was a case of local shock without general shock after an injury that was not considered very severe. Local shock and vasospasm of the brachial artery and its branches in a compound supracondylar fracture of the humerus which was relieved by reduction of the fracture have also been demonstrated.

Here early débridement, reduction, and adequate splinting played an important part in the relief of spasm while in the former case of the fractured tibia the reduction and splinting were not factors in relieving vasospasm.

TREATMENT OF CIRCULATORY DISTURBANCES OF THE EXTREMITIES FOLLOWING FRACTURE OR SEVERE TRAUMA

A. Prophylactic
   1. Adequate first aid; "splint 'em where they lie"; traction splints preferred, avoid constriction
   2. Early reduction and suitable fixation; limb moderately elevated; avoid constriction
   3. General measures to prevent thrombosis, as:
      a. Anticoagulants
      b. Hydration
      c. Keeping abdominal pressure down
      d. Regular breathing exercises
      e. Preventive measures against general shock
   4. Constant observation of circulation; ice bags locally, heat to other parts

B. Nonoperative Treatment
   1. Continued prophylactic measures (see A, 1-4)
   2. Relief of vasospasm
      a. Parasympathetic stimulants
      b. Procaine block of the controlling sympathetic nerves (5 or 10 c.c., 1 per cent procaine to each segment)

C. Operative Treatment
   1. Incision, release of subfascial pressure; reduction of fracture pressure on vessels and tissues
   2. Ligation, excision, or plastic repair; local stripping of paravascular sympathetics
   3. Thrombectomy or embolectomy
   4. Sympathectomy
   5. Amputation

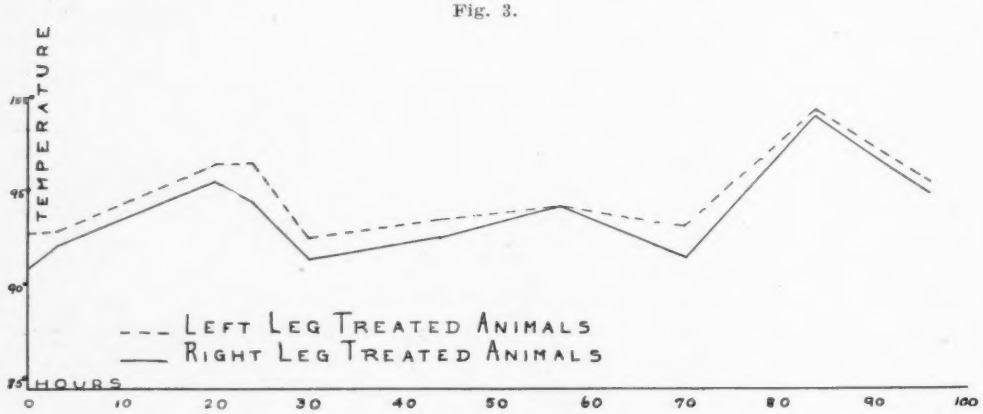
RESEARCH DATA WITH RESPECT TO TREATMENT OF LOCAL SHOCK

The use of a novocain block and its effect on the sympathetic mechanism in the treatment of local shock was stimulated particularly by the observations of Ochsner and DeBakey[11-13] with respect to the favorable results achieved by this method of releasing the vasoconstrictor mechanism in thrombophlebitis. Also, the observations of Leriche and Fontaine,[14] Smithwick and White,[15] White,[16] and Moon[17] in this relation were of importance. There seems to be a direct similarity between the traumatic circulatory phenomenon observed in local shock and that caused by a local infective process in the circulation (thrombophlebitis) which often proves to be a complicating circumstance.

Late in 1941 I started an experimental study to evaluate the significance and influence of a novocain block of the sympathetic control mechanism of an in-

jured extremity. This work was augmented by a grant from the National Research Council and carried out in the laboratories of the College of Pharmacy of the University of Nebraska. A preliminary report was given at the annual meeting of the American Academy of Orthopaedic Surgeons (Chicago, Ill., January, 1943)* and then presented in complete form at the annual meeting of the American Orthopaedic Association (Cleveland, Ohio, June 8, 1943).

Fig. 3.



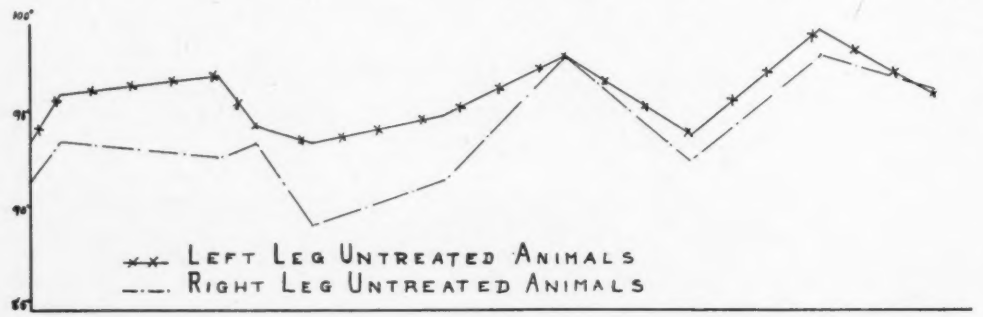


Fig. 4.

Fig. 3.—Graph of temperature (thermocouple) recordings of animals having right stellate novocain block following injury. Note how closely parallel the temperature curve of the injured right extremity follows that of the uninjured left extremity. (From Thomson, James E. M., Helwig, Ferdinand, and Sire, Eugene: J. Bone & Joint Surg. 26: 4, 1944.)

Fig. 4.—Graph of temperature (thermocouple) recordings of animals having no treatment following injury. Note the marked difference in the temperatures of the right injured extremity in relation to that of the left normal extremity (the right being much of the time 4 to 5½ degrees colder than the left). (From Thomson, James E. M., Helwig, Ferdinand, and Sire, Eugene: J. Bone & Joint Surg., 26: 4, 1944.)

Briefly the procedure was as follows:

1. The albino rabit was selected because the appearance of changes in the blood vessels of the ear are discernible. The right upper extremity of the animal was selected for injury because its sympathetic control comes from the right stellate ganglion. This ganglion similarly controls the blood vessels of the right ear and eye. Therefore, when a novocain block of the right stellate was accomplished the accuracy of the dilatory phenomenon was observed in the eye and ear. More than 300 rabbits were sacrificed during the study and finally

*This report was published in J. Bone & Joint Surg. 26: 189-196, 1944.

when a satisfactory sequence of technique was developed, 100 animals were consecutively observed and reported. They were all from the same stock, between 2 and 3 months old, and about 1,600 Gm. in weight.

2. An instrument was devised that would deliver a crush fracture of the right humerus with equal violence and at the same site. This fact was substantiated by roentgenographs.

3. Four hours after injury the region of the right stellate ganglion of fifty of the rabbits was injected with 3 c.c. of 2 per cent novocain solution. Each rabbit showed dilatation of the vessels of the ear.

4. Thermocouple temperature readings were made of the right and left forelegs of each rabbit at regular intervals (every four hours). The room was kept at a temperature of approximately 70° F. These animals were identified by number. Fifty rabbits having a novocain block of the right stellate ganglion were designated as *treated* in contrast to the fifty control animals (those not having a stellate block) which were termed *untreated*.

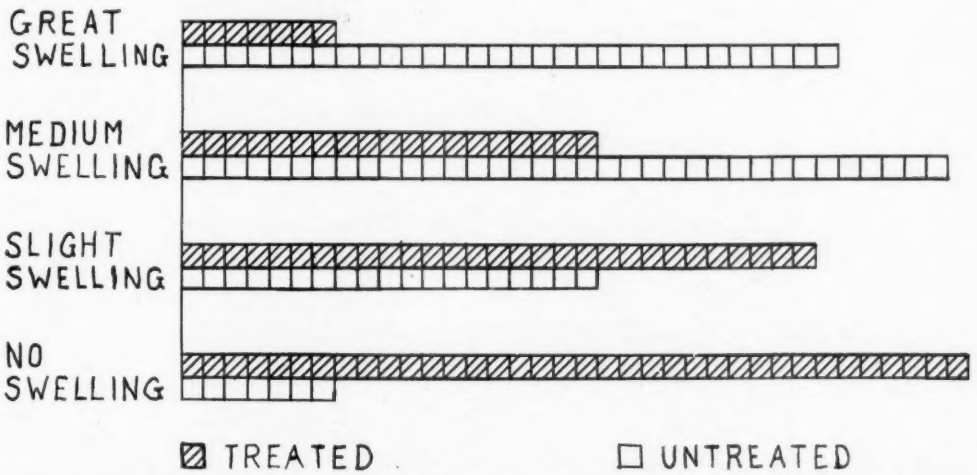


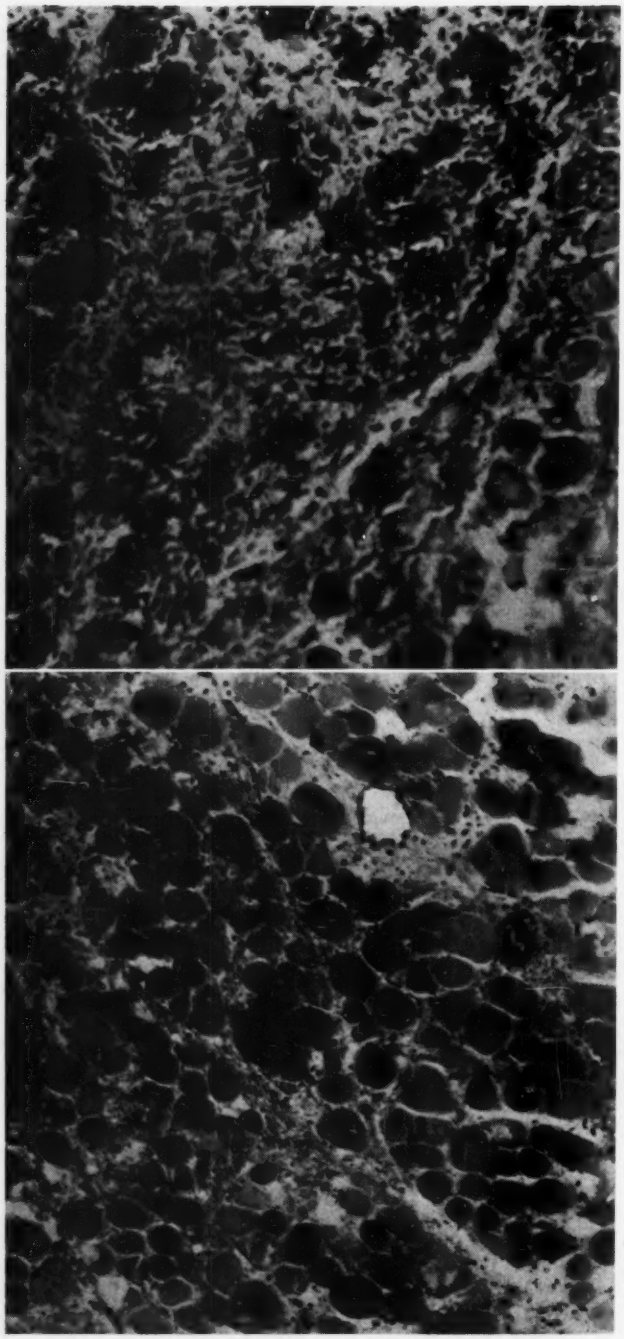
Fig. 5.—The shaded squares are estimations of the amount of swelling in the right injured extremity of animals having right stellate novocain block. The clear squares are similar observations of the control animals that had no treatment. Note that "great" and "medium" swellings are very pronounced in the control group while in the treated group the opposite occurs. (From Thomson, James E. M., Helwig, Ferdinand, and Sire, Eugene: J. Bone & Joint Surg. 26: 6, 1944.)

5. A glance at the composite graph (Fig. 3) demonstrates the fact that in those fifty animals having an injection of the stellate ganglion the temperature of the injured right leg ran slightly lower (from one to two degrees) and on a parallel course with that of the left uninjured leg.

6. A similar observation of the other graph (Fig. 4), illustrating the composite temperature curve of the fifty control animals, shows a wide variation in the temperature of the injured and uninjured extremity (the extreme of 5 degrees to 6½ degrees).

7. At regular intervals observations were made of the swelling of the extremities as to whether there was (a) great swelling, (b) medium swelling, (c) slight swelling, and (d) no swelling. The results of these observations are shown in Fig. 5. The shaded blocks show the percentage of great, medium, and

A.



B.

Fig. 6.—*A*, Rabbit 3. Right stellate ganglion injected with 3 c.c. of 2 per cent novocain four hours after injury. The microscopic sections show outstanding reactions of abundant fibroblastic response with one or two rather large areas of degenerated but nonnecrotic muscle and here and there focal, calcified, dead muscle fibers embedded in proliferating fibroblasts. Also there is organization of fibroblasts. This is a picture of an active healing process.

***B*, Rabbit 7. No treatment after injury. The section is made up almost exclusively of autolyzed, necrotic, nonviable muscle surrounded by a thin zone of fibroblasts. Sarcolemma neuclii are seldom seen. Little tissue response or active organization. A poor response to healing.**

slight swelling as well as no swelling in the animals having stellate injection of the injured side. There were only a few with great swelling but a large number with no swelling. Just the opposite is the case in the control animals. The findings almost make an "X" in their opposing directions.

8. One hundred hours after injury, all of the animals were sacrificed. The entire upper extremity was amputated. Microscopic studies were made of the tissue. One illustration each of a treated and a control tissue is shown, from Rabbits 3 (Fig. 6, *A*) and 7 (Fig. 6, *B*). The significance of such constant findings in over 80 per cent of the tissues studied is more than coincidental.

From the findings in Figs. 3, 4, and 5, we may assume that novocain block of the sympathetics controlling a severely injured extremity tends to restore circulatory integrity and equilibrium as manifest by the temperature curve and swelling response exhibited. Further, it is evidenced by the examination of the microphotographs of the tissue from the injured parts that the influence of stopping vasoconstriction also stimulates capillary competence and the interchange of tissue fluids, organization of a clot, the appearance of fibroblasts, proliferation of capillaries, calcification of necrotic muscle tissue, and an early healing process.

CLINICAL OBSERVATIONS

My opportunity to study local shock clinically has been quite limited. First, because I am not so located that I see a large number of severe injuries of the extremities; and second, because I am seeing fewer marked manifestations of local shock since I do a sympathetic novocain block almost routinely on all severe extremity injuries, if possible before distressing symptoms have an opportunity to display themselves. The following rather classical cases are illustrative.

CASE REPORTS

CASE 40-317.—The man was a truck driver. His truck was forced off the road and turned over, pinning the driver under the cab and his arm in the door. He was unconscious and could not be removed for one and one-half hours until a wrecker could be secured. Examination fourteen hours later, after a 100 mile trip in an ambulance, revealed multiple fractures of the pelvis, a dislocated hip, cerebral concussion, and a severe comminuted dislocation of the shoulder with extensive soft tissue contusion, as the shoulder was pinioned in the door (Fig. 7). There was a complete (transitory) brachial paralysis, absence of pulse at the wrist, and decoloration and coldness of the entire extremity. The systolic blood pressure was 70. There was severe local shock of the right upper extremity and severe general shock. He had been brought to the hospital for amputation of the upper extremity. Because of the patient's precarious condition, operative procedure could not be considered at that time. Mild traction was placed on the arm, traction on the dislocated left hip, and balanced hammock traction for the pelvis. General restorative measures for shock were resorted to, but in addition a 10 c.c. 1 per cent novocain solution was injected into the region of the stellate ganglion (technique described by Ochsner and DeBakey) with a startling result. The radial pulse was apprehended in five minutes. The extremity became warmer and the color improved almost immediately. Twenty-four hours later amputation probabilities were forgotten and the fracture dislocation of the shoulder and the hip was reduced also. The paralysis of the extremity rapidly improved. The patient made an uneventful recovery except for the fact that he developed an aseptic necrosis of a portion of the fractured head of the humerus which had to be removed. Fourteen months after the injury he was back at his

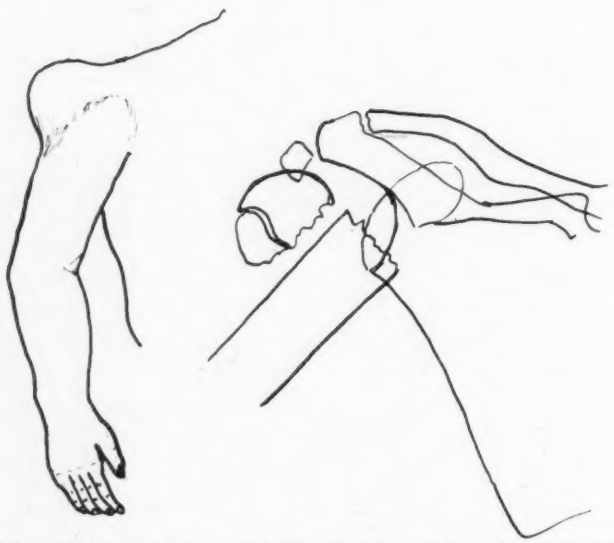


Fig. 7 (Case 40-317).—X-ray tracing of shoulder fracture dislocation and sketch of deformity.

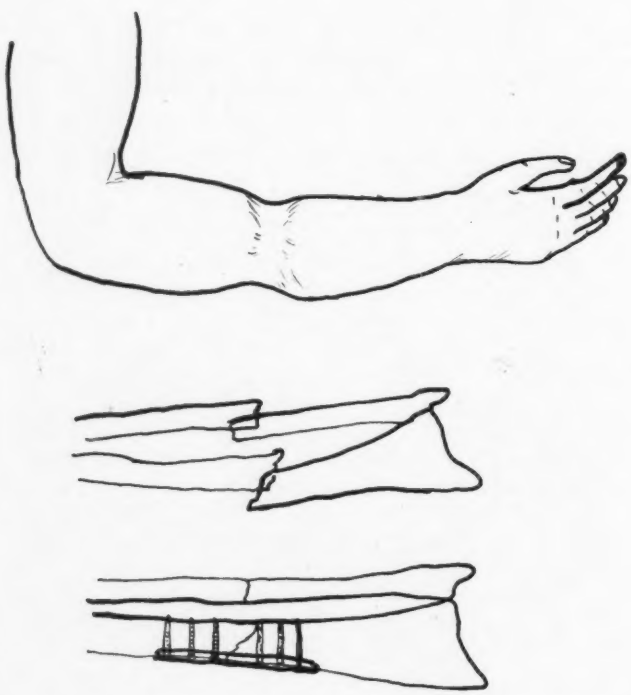


Fig. 8 (Case 43-451).—Sketch of circular constricting deformity following crushing fracture of forearm. Also x-ray tracings.

former occupation, with some disability in the right shoulder but with good strength, which allows him to handle heavy objects in and out of the large household moving truck he operates.

CASE 43-451.—The patient was a man 40 years of age, a tire repairman. While in the process of inflating a repaired tire it exploded from the rim striking him across the mid-forearm. A mid-forearm fracture was immediately recognized and splinted in a well-padded trough splint. Examination two and one-half hours later showed a marked circular retraction of the skin about the middle of the forearm (Fig. 8), resembling much in appearance the area of an extremity immediately after a tourniquet has been removed. There was a striking whiteness and decoloration. The radial pulse was absent but the ulnar was perceptible. The decoloration extended in degrees to the fingers, particularly the dorsal surface. Stellate block brought a prompt return of circulatory integrity but attempted reduction was unsuccessful in completely overcoming the overriding of the fragments. After one week of traction, open reduction was performed and an uneventful recovery resulted with complete restoration of function and a return to his former occupation.

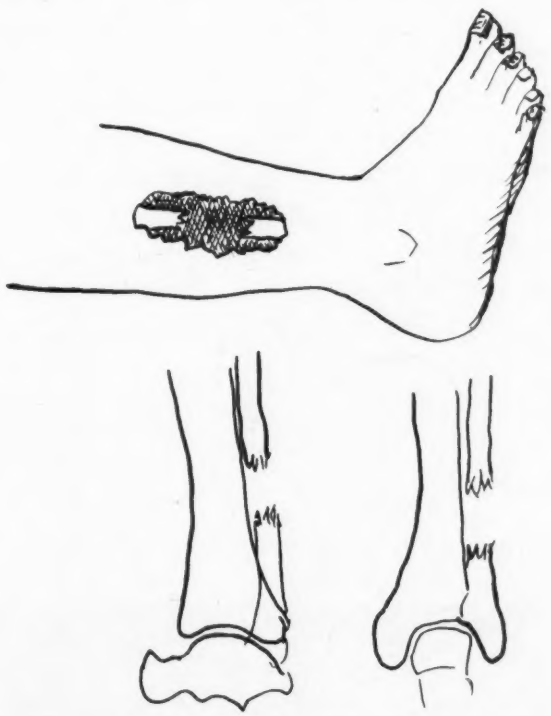


Fig. 9 (Case 43-469).—Sketch of site of wound and fracture of lower third of fibula. Note there was no injury of tibia.

CASE 43-469.—An 18-year-old farmer fell into a combine and the left leg was caught in the machinery. A matter of one-half hour was involved in extricating him and then a trip of forty-five miles was necessary with a dressing over the wound on the lateral aspect of the lower third of the right leg. The tissues had been ground and chewed out of the area which appeared to be 2½ inches wide and about 5½ or 6 inches long (Fig. 9). The black, greasy ends of the separated fragments of the fibula stood out in the crater of shredded muscle at the base. The tibia was uninjured. The margins of the wound were jagged and retracted. Decoloration of the area and of the toes was pronounced. The temperature of the toes was 5° F. below that of the left foot. We felt that here we were dealing with the early symptoms

Fig. 10 (Case 43-469).—Photograph of result after skin graft. The fibular defect replaced itself.

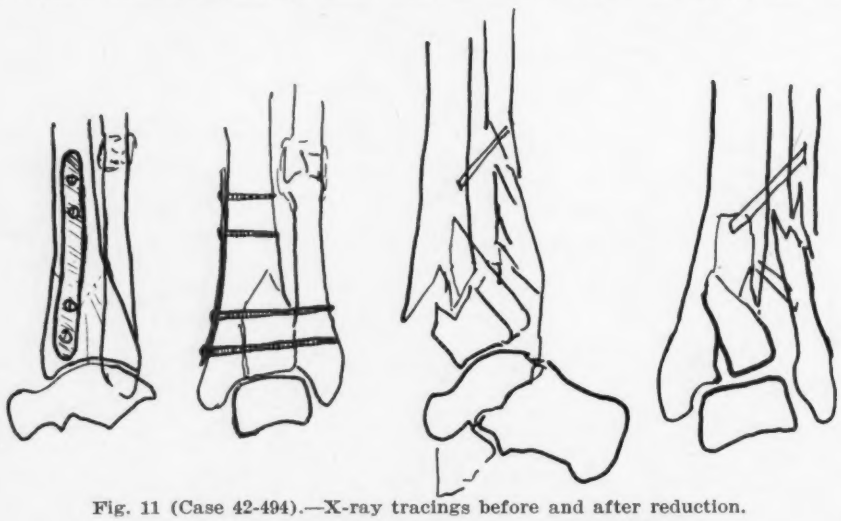


Fig. 11 (Case 42-494).—X-ray tracings before and after reduction.

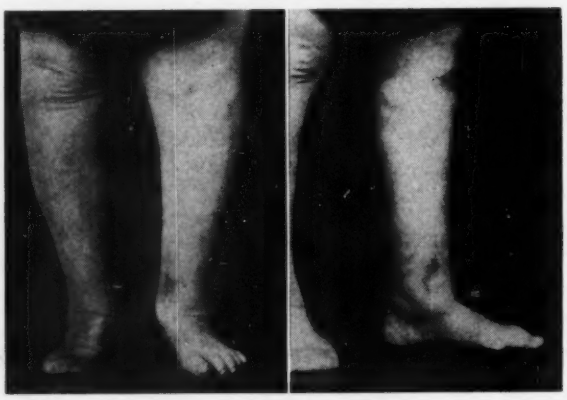


Fig. 12 (Case 42-494).—Photograph of result, good functioning ankle and foot. The pronation is about equal in both feet.

of local shock in a compound fracture in which crushing and tissue injury were not associated with loss of stability of the extremity. A lumbar sympathetic block was performed while the operating room setup was being made. By the time a complete wound toilet was accomplished the temperature of the injured foot was within 1° F. of the left foot. Cast fixation and sulfonamides were used and primary healing of a split-skin graft took place with complete regeneration of the fibular defect and no disability (Fig. 10).

CASE 42-494.—A 45-year-old farm housewife, while getting a cow around in a stall to milk her, was kicked in the region of the left ankle. As she fell, the cow stepped on her. There was marked contusion of the tissues on the outer side of the leg, causing a very severe comminuted fracture of the lower third of the fibula and lower end of the tibia with total disruption of the ankle joint (Fig. 11). When first examined twelve hours after the accident there was tremendous swelling of the lower leg and ankle. There was marked decoloration with extravasation of blood in the tissue and extensive contusion of the skin. The outer side of the ankle and the dorsum of the foot looked wet and almost gangrenous. The toes were cold and white. They were 4.5° F. colder than the toes of the right foot. A lumbar sympathetic block was carried out twelve and one-half hours after the injury and a good response was established. Gentle manual correction of the deformity was made and a plaster cast applied from the midthigh with the knee flexed 20 degrees and swung up in balanced suspension. Ultimately internal fixation was resorted to, thereby re-establishing the normal relationship of the bones of the ankle joint. Early active motion was established and in three and one-half months weight-bearing was allowed with a brace. Although she is a heavy individual she has practically normal use of the extremity and is doing her heavy work at home as usual (Fig. 12).

These are but four striking cases in a series of forty-eight experiences with the stellate and lumbar sympathetic block used to combat local shock in its various degrees of severity and as a prophylactic measure against its occurrence.

Those who are not familiar with the technique of performing the stellate and lumbar sympathetic block should familiarize themselves thoroughly with the anatomic relationships, hazards, and methods. In my experience the method described by Ochsner has proved unfailing and at the time of this writing I have had no mishaps.

CONCLUSION

The sympathetic block is not a panacea for all the grave complications of serious injuries of the extremities. It is just one infrequently used therapeutic and prophylactic measure with which the surgeon of trauma should be familiar and use with discretion more often. The more this method is used the more other potential favorable factors are recognized that occur with the earlier restoration of circulatory function which it brings to the extremity. I believe that the active restoration of tissue metabolism is a factor in inhibiting infection, promoting healing, and establishing callus in the region of fracture, thereby hastening the refunction for the extremity. Although my experimental data are inadequate to prove some of these assertions, the trend of their deductions and the clinical significance of some of the observations seem to justify the conclusions.

REFERENCES

1. Kroch, F.: Bietr. z. klin. Chir. **97**: 344, 1915; **108**: 61, 1917.
2. Doucastaing: Bull. Soc. méd. d. hôp., Paris **45**: 604, 1919.
3. Soubeyran, and Michon: Bull. Soc. méd. d. hôp., Paris **44**: 805, 1911.

4. Cohen, S.: Lancet, 707, 1941.
5. Homans, John: Circulatory Diseases of Extremities, New York, 1939, The Macmillan Company.
6. Montgomery, A. H., and Ireland, J.: J. A. M. A. **105**: 1741, 1935.
7. Henry, John P.: Am. J. Surg. **56**: 49, 1942.
8. Jones, S. G.: J. Bone & Joint Surg. **17**: 659, 1935.
9. Jones, S. G.: Am. J. Surg. **43**: 325, 1939.
10. Volkmann: (Reprint) Jour. Internat. Chir. **3**: 77, 1938.
11. Ochsner, A., and DeBakey, M.: SURGERY **5**: 491, 1939.
12. Ochsner, A., and DeBakey, M.: J. A. M. A. **112**: 230, 1939.
13. Ochsner, A., and DeBakey, M.: Surg., Gynec. & Obst. **70**: 1058, 1940.
14. Leriche, R., and Fontaine, R.: Presse méd. **42**: 849, 1934.
15. Smithwick, R. H., and White, J. C.: Surg., Gynec. & Obst. **51**: 394, 1930.
16. White, J. C.: J. A. M. A. **94**: 1382, 1930.
17. Moon, V. H.: Shock and Relation to Capillary Phenomena, London, 1938, Oxford University Press.

MALIGNANT GRANULAR CELL MYOBLASTOMA OF THE GLUTEAL REGION

LAUREN V. ACKERMAN, M.D.,* AND C. RAY PHELPS, M.D.†

GRANULAR cell myoblastoma is invariably considered a benign tumor and treated as such.[1] It is, therefore, important to be aware of the malignant variants so that a more enlightened attitude toward treatment and subsequent follow-up may be engendered.

CASE REPORT

B. G., a 21-year-old woman, was first admitted to the hospital on Nov. 13, 1942. In September, 1940, the right hip was injured by a fall and a lump developed soon after in this location. It was incised by a local physician because it was thought to contain pus. Pain developed locally and in January, 1941, the tumor was inadequately excised. A short time later, a recurrence appeared, for which eight x-ray treatments were given to the region of the right hip. There was temporary relief of pain, but for the few months previous to admission, it was severe and localized to the region of the right hip and sacroiliac areas.

Physical examination revealed a fairly well-developed, somewhat undernourished, white woman. Over the posterolateral surface of the right hip there was evidence of radiation reaction with skin atrophy and telangiectasia. It was possible to flex the thigh, extend it, and rotate it medially or laterally with only slight pain. The right knee and ankle were normal. A roentgenogram of the chest showed evidence of early pulmonary metastases and the patient was therefore discharged without specific treatment on Feb. 24, 1943 (Fig. 1).

On Feb. 23, 1944, the tumor had increased in size with resultant contracture of the right knee which could not be extended more than 90 degrees. A repeat roentgenogram of the chest showed progression of the pulmonary metastases (Fig. 2). The views of the skull were negative. Roentgenograms of the lower lumbar vertebrae and pelvis revealed an osteolytic process involving the greater portion of the right sacral and adjacent iliac bone. Metastatic changes were also present in the left iliac bone, the pubic bone, the visualized portion of each femur, and the fifth lumbar body.

The patient became bedfast, developed decubitus ulcers, and was last admitted to the Kansas City General Hospital on April 29, 1945. Roentgenograms of the chest and pelvis showed excessive increase in the extent of the disease (Figs. 3 and 4) and death occurred on July 14, 1945. Permission for post-mortem examination was obtained.

Anatomic Diagnosis.—Diagnosis was granular cell myoblastoma of the right gluteal region with metastases to the regional nodes, lungs, innominate bone, sacrum, and lumbar vertebrae; pyelonephritis, kidney stones, bronchopneumonia, decubitus ulcers, ascites, hydrothorax.

The body was extremely emaciated and there was a large, nonulcerated tumor mass over the right hip, which presented extreme skin atrophy and telangiectasia (Figs. 5 and 6). A small decubitus ulcer was present over the sacrum. There were approximately 2,000 c.c. of fluid in the peritoneal cavity. In the right lower quadrant there was a large retroperitoneal mass which displaced the ascending colon, small bowel, and pelvic organs to the left. Each pleural cavity contained about 1,000 c.c. of clear fluid. The right lung weighed 605 Gm., and the left, 660 Gm. The surface of the lungs showed numerous nodulations of variable sizes, some of them forming grapelike masses (Fig. 7). These tumor masses felt rather rubbery and, on section, were circular, homogeneous, and gray, with small areas of hemorrhage (Fig. 8). They replaced about 80 per cent pulmonary parenchyma but had not ulcerated through the pleura. The bronchi and pulmonary vessels were not remarkable. The kidneys showed some small stones within the calices and the corticomedullary zone was com-

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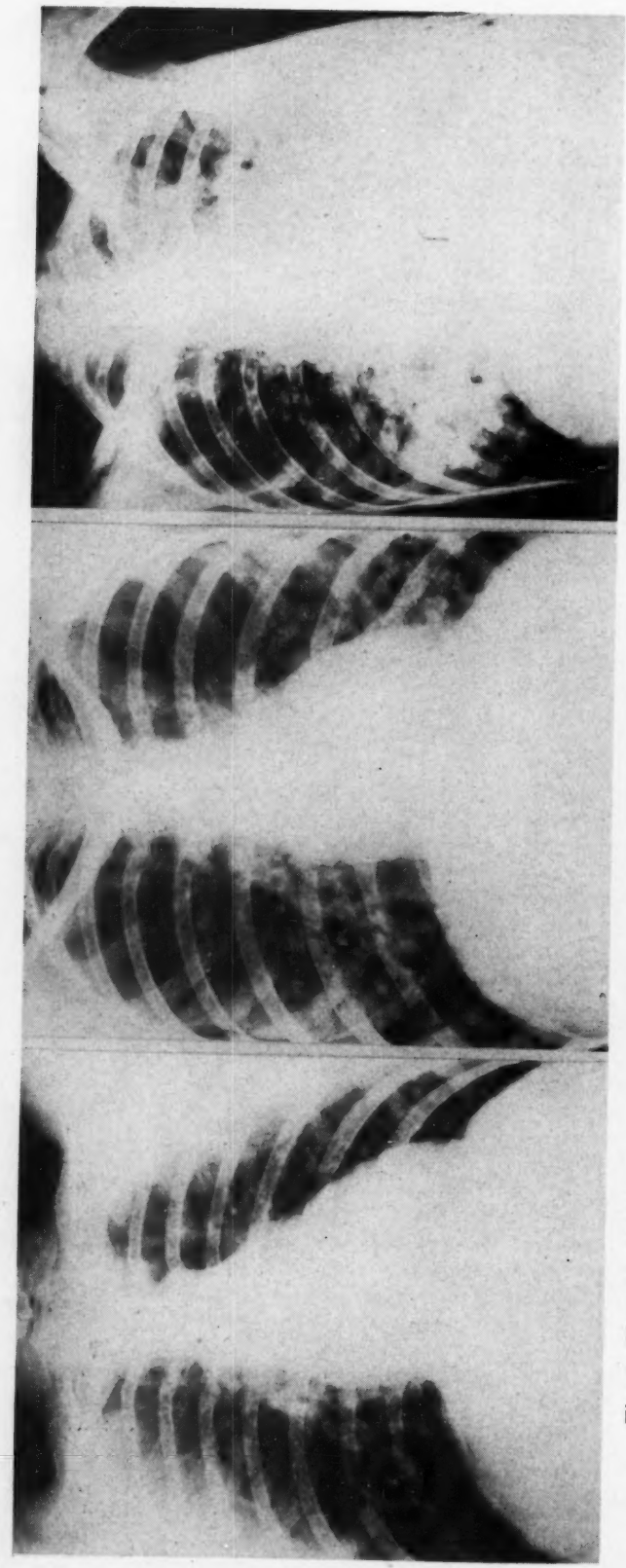


Fig. 1 (Nov. 14, 1942). Fig. 2 (Feb. 15, 1944). Fig. 3 (May 6, 1945).

Figs. 1 to 3.—Note progression of metastases.

pressed. The ureters were dilated and the bladder congested. The tumor mass in the right lower quadrant was retroperitoneal in nature and communicated with the large mass in the region of the hip. It had extended into the ilium, sacrum, and contiguous lumbar vertebrae and had partially blocked the ureters. The bone was so completely destroyed by tumor (yellow in color with zones of hemorrhage) that only small spicules remained. The brain was not remarkable.

The tumor showed a somewhat varying morphology. Tumor cells assumed at times a pseudoalveolar arrangement (Fig. 9). Individual cells varied from very small to large. Often, they had coarsely granular, eosinophilic cytoplasm. In the larger cells, the nuclei were located eccentrically, while in the smaller cells, they tended to be central. The nuclei usually were well defined and had very prominent nucleoli (Fig. 10). Occasional cells showed condensation of the chromatin. No mitotic figures were seen. Rather frequently, individual cells were multinucleated (Fig. 12). The tumor in the lung as well as in the bone formed solid masses which were well vascularized and carried with them very little stroma. When tumor was present in a lymph node it usually completely replaced it. Tumor in the previously radiated area showed no discernible changes. The tissue surrounding the tumor in this area did show extreme fibrosis and other expected radiation alterations.

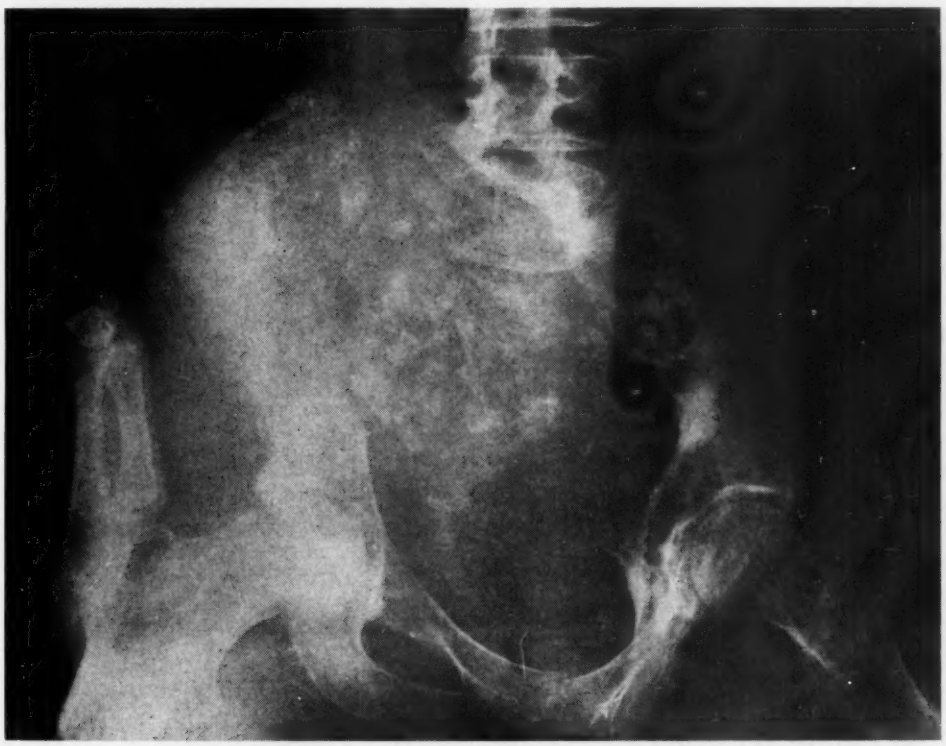


Fig. 4.—May 6, 1945; note extensive osteolytic destruction of the innominate bone.

The tumor was fixed in 10 per cent formalin, Zenker's acetic, and 100 per cent alcohol. A determined search was made for evidence of cross striations, and in one slide, a large cell showed definite fibrils (Fig. 13). There were also small groups of red granules in some of the cells, with an irregular linear arrangement which may represent the precursor of fibrils.[2]

Because of some cytoplasmic vacuolation in some of the cells, a stain for fat was done, showing scattered small amounts of sudanophilic substance within these areas. No intranuclear fat was present. Stain for glycogen demonstrated a peripheral intranuclear halo of glycogen by Best's carmine stain. A Wilder reticulum stain showed a rather unusual distribution of reticulum. This reticulum enclosed groups of cells (Fig. 11).

Fig. 5.

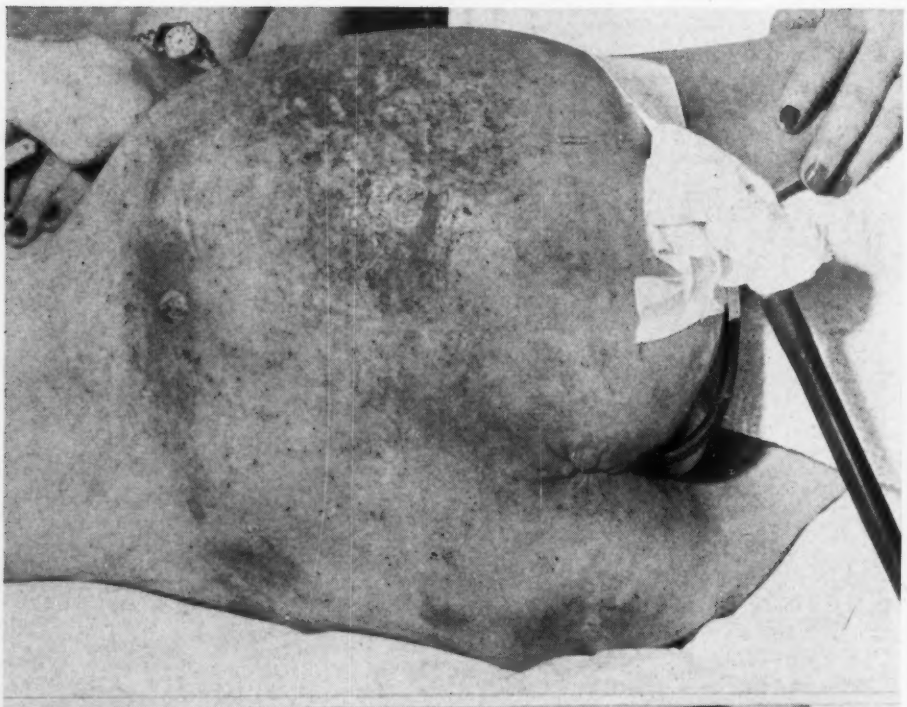
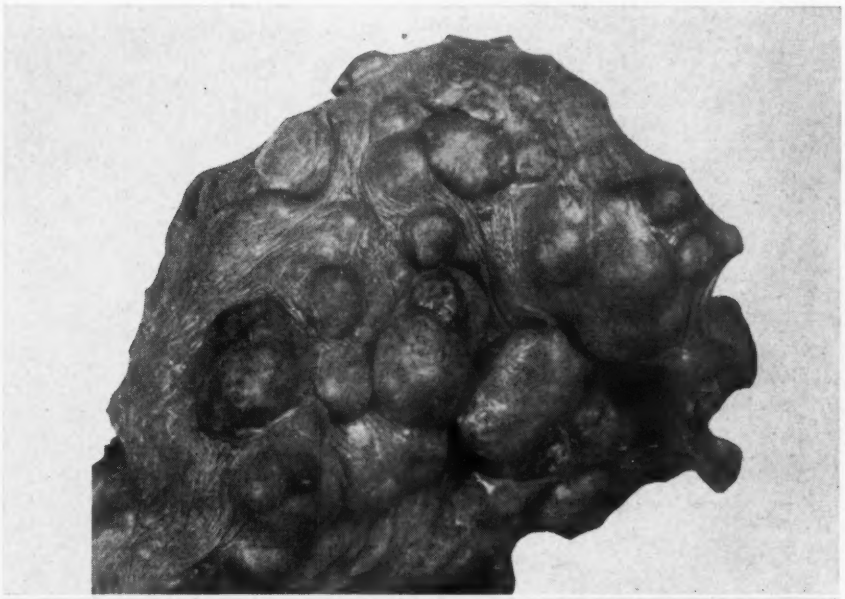


Fig. 6.

Figs. 5 and 6.—Huge soft-tissue tumefaction with skin atrophy.

Fig. 7.



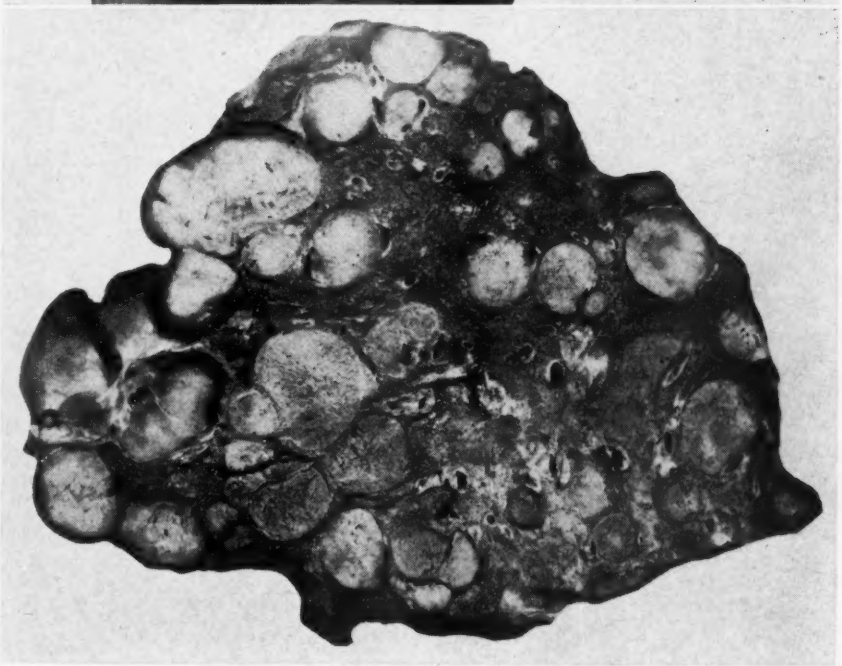
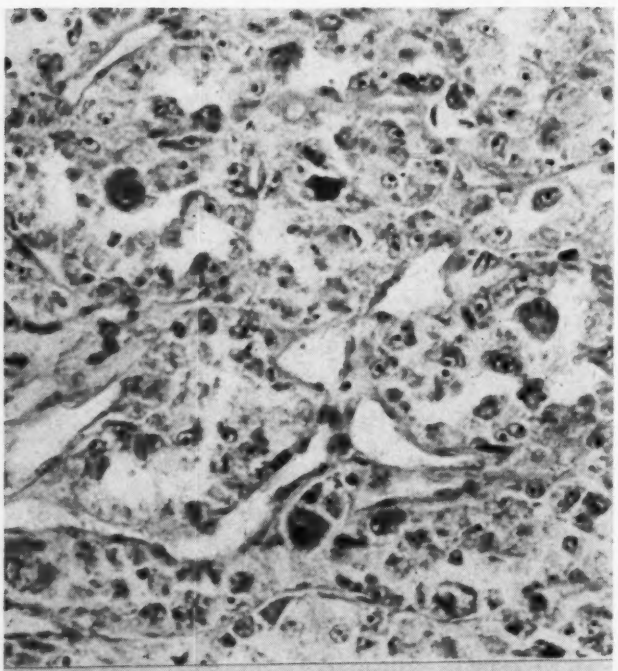


Fig. 8.

Fig. 7.—Pleural surface of lung, showing numerous tumor nodules.
Fig. 8.—Cut section of lung demonstrating well-delineated, innumerable metastatic foci.

Fig. 9.



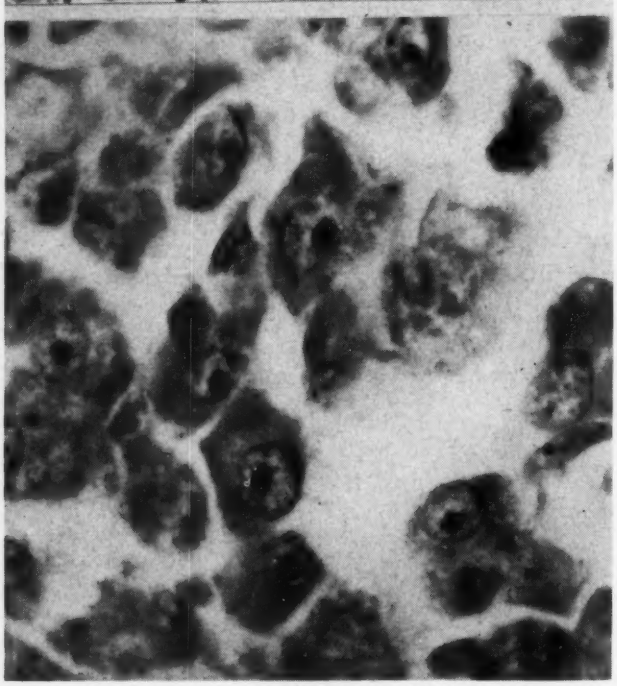


Fig. 10.

Fig. 9.—Photomicrograph (low power); pseudoalveolar arrangement of well-vascularized tumor.

Fig. 10.—Photomicrograph (high power); characteristic well-defined nucleus, prominent nucleoli, and granular cytoplasm.

Fig. 11.

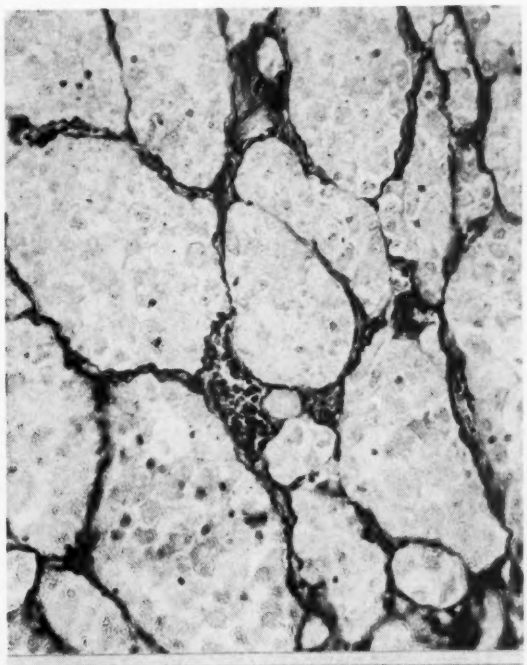


Fig. 12.

Fig. 11.—Note pattern of reticulum.
Fig. 12.—Photomicrograph (very high power); multinucleated cells.

DISCUSSION

Abrikossoff[3, 4] classified these tumors into four types, the first three of which were benign and the fourth, malignant. The cellular morphology of this tumor was similar to his third type. In the benign granular cell myoblastomas, the nucleoli are not as prominent and cell variation is minimal. In Table I are represented some of the cellular differences between the benign and malignant myoblastomas.

There has been no report in the literature of a granular cell myoblastoma showing metastatic disease until recently when Ravich and associates[5] reported one arising from the urinary bladder. The individual cellular details of our case resembled his.[6]

Fig. 13.—Photomicrograph (very high power); note wavy cross striations in cell marked by arrows.

This is apparently the first case of malignant granular cell myoblastoma arising in the gluteal region and causing death from metastatic involvement of bone and lungs. It is interesting that this patient lived almost five years after the diagnosis was made, and that there were proved lung metastases for almost three years.

If, after biopsy, there is any question of malignancy, a radical rather than a conservative operation should be done. These cases should also be followed rather more closely than has been felt necessary in the past and probably regional node areas should be watched and roentgenograms of lungs taken. If lymph node metastases develop, regional dissection may be indicated. Radiotherapy is not warranted.

TABLE I

	BENIGN	MALIGNANT
Size of cells	20 to 60 μ; up to 300μ	8 to 20μ; average 4μ (Malignant measurements based on this case only)
Size of nuclei	7 to 10μ	6 to 17μ; average 9μ (Malignant measurements based on this case only)
Character of nucleoli	Fine	Very prominent
Glycogen	No available data	Intranuclear present; cytoplasmic absent
Fat	Absent	Minimal cytoplasmic
Longitudinal and cross striations	Present	Absent in one case (Ravich); present in our case
Cytoplasm	Granular	Granular

SUMMARY

A malignant granular cell myoblastoma (third group of Abrikossoff) is reported arising from the region of the right hip. It recurred and metastasized following inadequate excision and caused death approximately five years after diagnosis. This is the second example of this type of tumor metastasizing and is the first example of one in this location. It is recommended that a somewhat more cautious clinical attitude be entertained when a diagnosis of granular cell myoblastoma is made. The typical cellular morphology of the malignant variant has been detailed. If any doubt exists as to its benign character, then radical rather than conservative therapy should be instituted. Radiotherapy is not indicated.

REFERENCES

1. Crane, A. R., and Tremblay, R. G.: Myoblastoma (Granular Cell Myoblastoma or Myoblastic Myoma), Am. J. Path. **21**: 357, 1945.
2. Crane, A. R.: Personal communication.
3. Abrikossoff, A. I.: Ueber Myome, ausgehend von der quergestreiften willkürlichen Muskulature, Virchows Arch. f. path. Anat. **260**: 215, 1926.
4. Abrikossoff, A. I.: Weitere Untersuchungen über Myoblastenmyome, Virchows Arch. f. path. Anat. **280**: 723, 1931.
5. Ravich, A., Stout, A., and Ravich, R. A.: Malignant Granular Cell Myoblastoma Involving the Urinary Bladder, Ann. Surg. **121**: 316, 1945.
6. Stout, A. P.: Personal communication.

DYSGERMINOMA OF THE OVARY

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COMPARATIVELY recent in medicine was the separation of this growth as a distinct type from the other neoplasms of the ovaries. Meyer[1] originally identified this tumor of the ovary which is so histologically similar to the seminoma of the testicle. Since it arises from the undifferentiated sex cells of the primitive mesenchyma of the early embryonic life, he called this neoplasm dysgerminoma. He also made three striking observations—a tendency to occur in the younger age group, predilection for the right side, and high percentage of occurrence in hermaphroditic or pseudohermaphroditic states. Some 160 cases have been reported in the literature up until 1940.

The incidence of occurrence of this type of new growth among the malignant tumors of the ovary, according to Klaften,[2] has varied from 3.1 to 6.3 per cent among the groups of cases reviewed. This seems to be somewhat higher than that found in the series of the author who had 1.2 per cent. The mortality varies between 40 to 60 per cent with recurrence and metastasis about as frequent.

One of the best criterions as to the benign or malignant state is the gross findings at surgery, as those that are infiltrative and have involved the regional lymphatics are usually malignant, and vice versa.

Most frequently the patient presents herself with the only complaint being fullness in the stomach or often an actual enlargement of the abdomen. Pain, excessive bleeding, and dysmenorrhea rarely bring her to the office. At that time the pelvic examination usually reveals the adnexal mass and close observation will sometimes bring out pseudohermaphroditic characteristics, such as masculine voice or enough facial hair to require shaving. An approach to the preoperative diagnosis has been attempted by hormone studies, but as this is a sexually undifferentiated tumor, the findings are always negative and the diagnosis is made at surgery.

Although this condition occurs more frequently in the younger age group, and has been sometimes regarded as benign, it is to be stressed that it should be looked upon as malignant and should be thought of in diagnosing tumors in women at any age. Abernethy[3] reported a case in a 22-year-old patient encountered during a section. Kirshbaum and Newman[4] reported one in a 36-year-old woman and the one I am reporting is in a girl 12 years old. All three were malignant and in varying age groups. Many times this condition was diagnosed as benign by the operating surgeon only to be disproved by the pathologist's necropsy report.

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The successful treatment is an early operation, for if the tumor has progressed to the extent of producing abdominal fluid, adhesive reactions to the near structures, or actual extension, then the cases are fatalities. But in those that are discrete and have had a clean surgical removal, the patients usually survive. X-ray therapy has not proved to be of value.

CASE REPORT

CASE S1279.—A 12-year-old Spanish girl had a chief complaint of "lump in stomach." This child had always been thin and nervous until two years before admission. At the age of 10 her mother stated she began to get "fat all over." About two and one-half years before admission the patient had a complete examination in a clinic at which time all findings were negative. During a routine school physical examination two months before, a mass was found in the abdomen and the girl was sent in for diagnosis and treatment. She had no vaginal bleeding of any kind, not having started to menstruate, but the breasts had become more developed in the previous three or four months. Other history was entirely uninformative as the patient was quite normal in habits, growth, and associations.

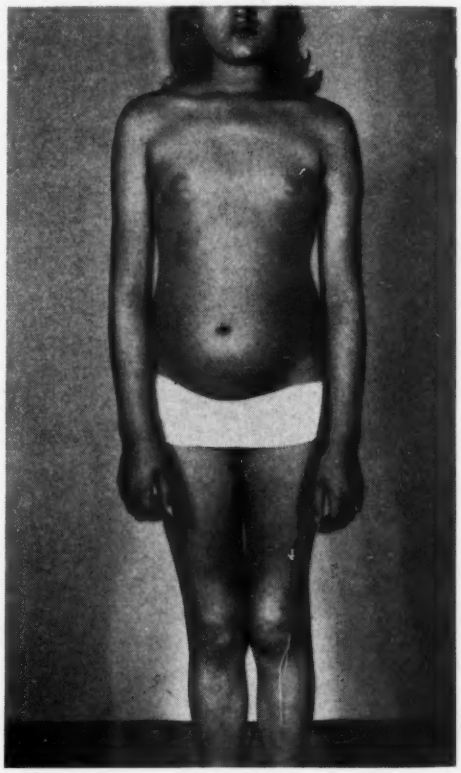

Fig. 1.—Normal 12-year-old girl, except for evident abdominal enlargement.

Physical examination on entrance revealed a 12-year-old girl, feminine in type, well nourished, in no acute distress. Temperature and pulse rate were normal. Breasts were beginning virginal development. The abdomen was rounded and there was beginning pubic hair which had normal female distribution. There was a firm, nontender, irregular, freely movable mass to the left. The lower border was resting on the pubic, medial border at the midline, and superiorly two fingers above the umbilicus. On rectovaginal examination the uterus could not be differentiated from the mass above.

Laboratory procedures were normal; x-ray examinations of the chest and bones were negative. Roentgenograms of the abdomen showed a large homogeneous, soft tissue density.

A diagnosis of a left ovarian cyst was made and the patient was operated upon. At surgery there was removed a large mass replacing the left ovary. It was discrete, firm, not adhered, or infiltering any of the abdominal viscera. The left tube, uterus, right tube, and ovary were entirely normal. No other pathology was noted in the abdomen.

Pathology Report.—Following is the complete gross and microscopic report of the mass removed at surgery. From the left ovarian tumor the gross specimen consisted of a large, pale gray, solid tumor, weighing 1,050 Gm., measuring 18 by 12 by 6.5 cm. The surface was rather smooth, but slightly bosselated. At one point it was slightly puckered. The cut surface was opaque, grayish white, firm, the tissue cutting with some resistance. Scattered throughout were small patches of hemorrhage and paler semitranslucent areas of degeneration. No cystic areas were present.

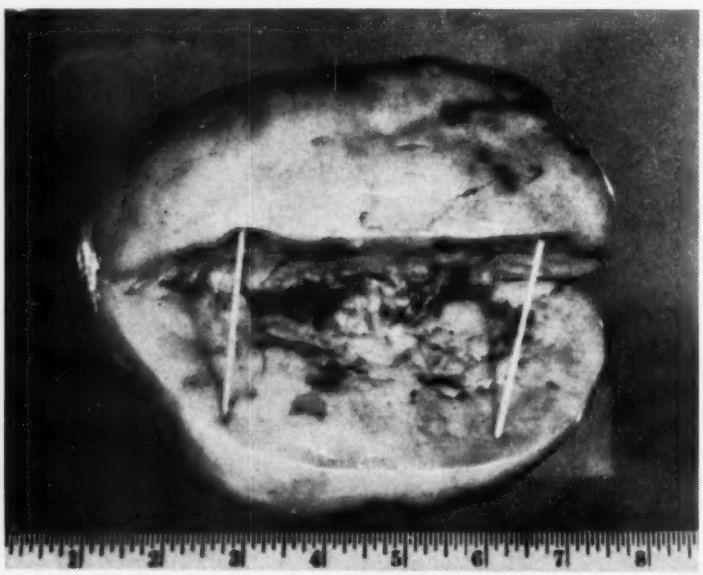

Fig. 2.—Cut section removed at surgery; numerals in inches.

Microscopically, the sections were cut from a number of various portions of the tumor. These varied from one another in appearance. The tumor cells extended outward to the fibrous capsule. No break through the capsule was observed. The tumor consisted of irregular cords and nests of large, immature-appearing cells, possessing round or polyhedral, vesicular nuclei, showing frequently one large nucleolus. These large nuclei were surrounded by a small amout of pale-staining, frequently granular, faintly bluish-pink cytoplasm. In other areas the cytoplasm was more reticular, and fainter staining. The cells varied somewhat in different portions of the tumor. They were supported by variable amounts of dense fibrous stroma. In the more central portions of the tumor the stroma was minimal in amount, and was infiltrated with a scattering of lymphocytes. Nearer the periphery the fibrous stroma was thicker, and occasionally supported a small rounded structure, somewhat resembling an immature follicle. Mitotic figures were present in large numbers. Many were atypical. The gross and microscopic appearance of the tumor was consistent with the diagnosis of dysgerminoma of the ovary.

The patient had an uneventful postoperative recovery, being discharged on the tenth hospital day. She was seen at various intervals at the follow-up clinic, and eighteen months after surgery a complete check of the child revealed no evidence of recurrence or metastasis.

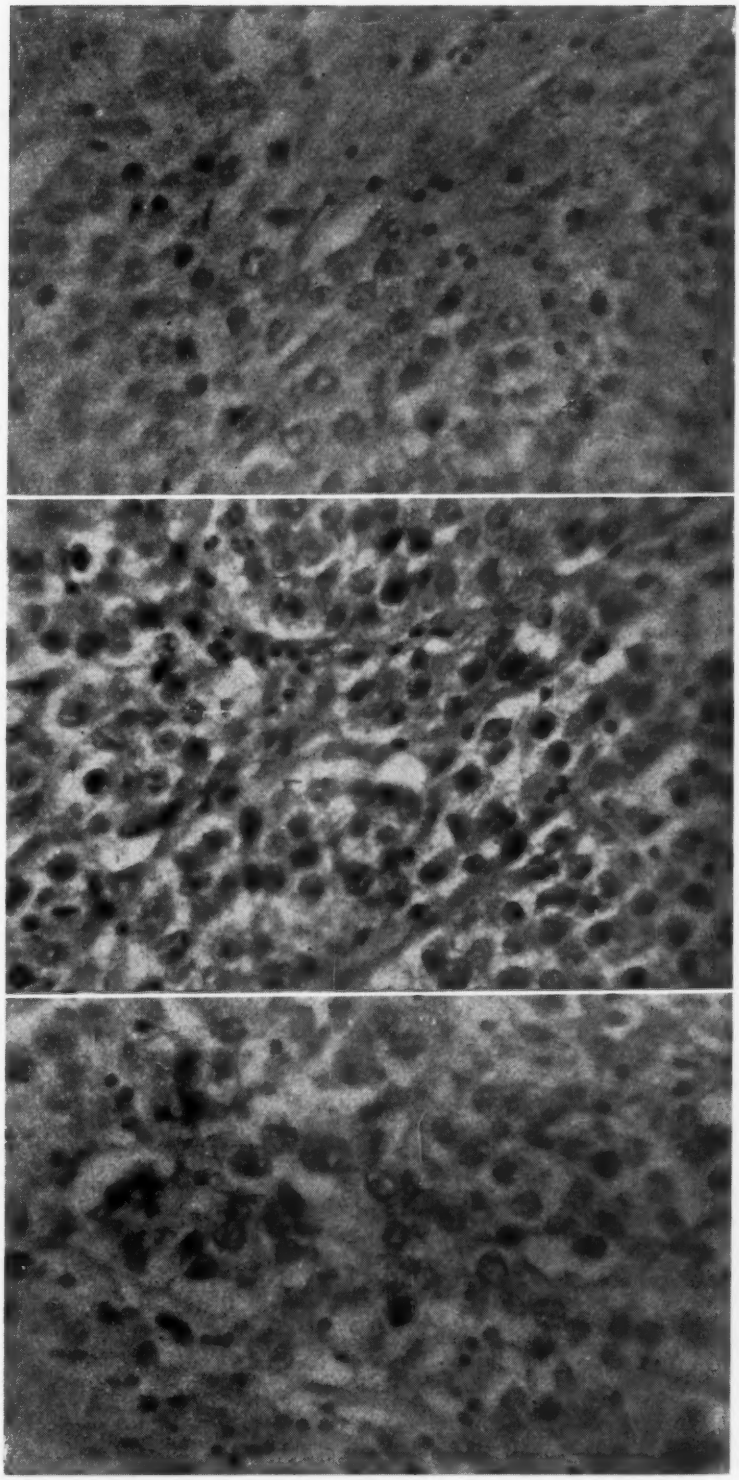

Fig. 3.—Microscopic section taken from gross specimen shown in Fig. 2.

SUMMARY

1. Review of the literature shows some divergence of opinion as to the benign or malignant state of these tumors.

2. Reports of cases of survival (both in the literature and in my series) are those in which the primary growth showed no evidence of extension.

3. These tumors are not radiosensitive.

4. Asymptomatology; normal secondary sex characteristics, and any age group are more often found than the reverse.

CONCLUSION

Having an incidence of 3 to 6 per cent among all malignant tumors of the ovary, and a mortality of 40 to 60 per cent with recurrence and metastasis as frequent, these growths have assumed an important proportion. The only hope for these patients is early diagnosis and surgery. These are malignant tumors, as all those that showed extension at the time of operation died of metastasis.

REFERENCES

1. Meyer, Adolph: Am. J. Obst. & Gynec. **22**: 1930.
2. Klaften, E.: Arch. F. Gynäk. **158**: 544, 1934.
3. Abernethy, D. A.: J. Obst. & Gynaec. of Brit. Emp. **50**: 278, 1943.
4. Kirshbaum, J. D., and Newman, B.: Am. J. Obst. & Gynec. **45**: 33, 1943.

THE USE OF TETRAETHYLAMMONIUM IN PERIPHERAL VASCULAR DISEASE AND CAUSALGIC STATES

A New Method for Producing Blockade of the Autonomic Ganglia

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THERAPY in peripheral vascular disease cannot properly be applied without an evaluation of the presence and degree of vasospasm in the involved and collateral vessels.[1, 9, 10] In the majority of cases both a functional element of vasoconstriction and an organic component of vascular obliteration are present. The functional component, since it is, for the most part, an expression of the activity of the sympathetic nervous system, may be altered; the organic component, on the other hand, is little, if ever, modified by therapeutic measures.

The role of vasoconstriction has been evaluated in the past by means of local nerve block, paravertebral sympathetic block, and spinal anesthesia. Recently, a new method of producing a blockade of autonomic ganglia by means of parenteral injection of the tetraethylammonium ion has been introduced. It is the purpose of this report to describe the use of this compound in peripheral vascular disease and causalgic states.

Acheson and Moe[2, 3] studied the action of tetraethylammonium on the superior cervical and stellate ganglia, on sympathetic vasoconstrictor mechanisms, and on efferent vagal pathways. They concluded that the response of the nictitating membrane, the blood pressure, and the heart rate could all be explained by a blockade of autonomic ganglia, both sympathetic and parasympathetic. The validity of this interpretation was further confirmed by Acheson and Pereira.[4]

Lyons and co-workers[5, 6] demonstrated that the drug could be administered safely to man in doses sufficient to produce an autonomic blockade and described its action on the human subject.

TECHNIQUE OF THIS STUDY

Studies on the peripheral circulation were carried out with the patient recumbent, extremities uncovered, in a room temperature between 70 and 75° F. After a suitable period of rest, whenever possible, in the basal state, skin temperature readings were recorded on symmetrical areas of the extremities studied. The color of the skin and the volume of the pulses were noted. After suitable control studies had been made, tetraethylammonium was injected intravenously or intramuscularly in a 10 per cent solution and further observations were made.* The intravenous dose ranged from a minimum of 100 mg. (1 c.c.) to a

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maximum of 500 mg. (5 c.c.). This was injected slowly over fifteen to sixty seconds, using significant changes in the volume of the pulse and the general reaction of the patient as a guide to cease or delay further administration of the drug.

Intramuscular injections were utilized to prolong the effect of the autonomic blockade only in patients under observation in the hospital. These were given in doses less than 20 mg. per kilogram of body weight, 1.0 to 1.5 Gm., one-half the dose administered in each buttock.

The intravenous administration produces a metallic taste in fifteen to twenty seconds followed by a sense of numbness and tingling in the extremities which is associated usually with a fall in blood pressure in hypertensive patients and with a rise in heart rate. Sweating, if present, stops, the mouth becomes dry, and there is incomplete dilatation of the pupil with loss of accommodation. With the fall in blood pressure, there is an increase in skin temperature of the toes or fingers usually within five minutes which persists after the blood pressure returns to its initial level. Though the blood pressure in the supine position returns to its initial level, postural hypotension may exist in diminishing intensity for fifteen to sixty minutes. The vasoconstrictor gradient present in the extremities is largely abolished so that toe and thigh temperatures are equalized.

VALUE OF TETRAETHYLAMMONIUM IN PRODUCING SYMPATHETIC BLOCK AS DEMONSTRATED BY COMPARATIVE TESTS

The comparative effects on peripheral blood flow of lumbar sympathetic block, spinal anesthesia, local nerve block, and sympathectomy versus tetraethylammonium, as measured by skin temperature and clinical response, were measured both in patients with vascular disease and in a control group of relatively healthy individuals. Fifty-five comparative tests were performed (Table I). Measurements of skin temperature response were made under identical conditions in practically all cases.

TABLE I. COMPARATIVE SKIN TEMPERATURE RESPONSE (PERIPHERAL BLOOD FLOW) OF TETRAETHYLAMMONIUM BROMIDE AND THE USUAL METHODS OF PRODUCING SYMPATHETIC BLOCK

NUMBER OF COMPARATIVE TESTS—55		RESPONSE TO TETRAETHYLAMMONIUM BROMIDE		
		EQUAL	LESS	GREATER
Paravertebral sympathetic block	10	2	0	8
Local nerve block	10	1	0	9
Spinal anesthesia	10	2	1	7
Sympathectomy	25	20	2	3
Total	55	25	3	27

It will be noted that the response to tetraethylammonium bromide was equal to or surpassed the response produced under identical conditions by paravertebral sympathetic block or local nerve block. In one instance, in ten it proved inferior to spinal anesthesia, and in two instances, in twenty-five it proved inferior to sympathectomy in producing a maximal temperature response. In fifty-two of fifty-five comparative tests it proved equal or superior to the usually accepted methods of producing sympathetic block. The ease of

administration regarding the technical procedure is an additional highly desirable feature of tetraethyl ammonium, since spinal anesthesia is not always desirable or possible and paravertebral sympathetic block, even in expert hands, is not always successful.

UTILIZATION OF TERTAETHYLAMMONIUM BROMIDE AS A DIAGNOSTIC AND THERAPEUTIC MEASURE

Approximately 500 patients have received tetraethylammonium bromide or chloride on one or more occasions either as a diagnostic or therapeutic measure, or both. These patients, for the most part, fall into two general groups, (1) patients with hypertension, and (2) patients with peripheral vascular disease and allied disorders. The various diseases studied in this latter group have included patients with peripheral arteriosclerosis obliterans (all stages); thromboangiitis obliterans (including cases with migratory superficial phlebitis); functional vascular disorders including Raynaud's syndrome, livedo reticularis, acrocyanosis and other unclassified vasomotor disorders; causalgias including various types of reflex sympathetic dystrophy;[13] superficial and deep thrombophlebitis with and without evidence of vasospasm, various types of lymphedema, post-traumatic edema, scleroderma, endarteritis, herpes zoster and post-herpetic neuralgias, trench and immersion foot sequelae, and a nondescript group of widely varying nature.

Many of these patients received courses of therapy extending over a period of several days. Others received only a single injection, usually intravenously, or were given periodic weekly or monthly injections to produce a sympathetic block as the need arose.

TECHNIQUE OF ADMINISTRATION

Tetraethylammonium bromide was administered as a 10 per cent solution (100 mg. per cubic centimeter) in practically all cases. The drug was given either intravenously or intramuscularly. The intravenous dose ranged from a minimum of 100 mg. (1.0 c.c.) to a maximum of 500 mg. (5.0 c.c.). The drug was administered intramuscularly on the basis of 20 mg. per kilogram, the maximal dose usually ranging from 1.0 to 1.2 Gm. (10 to 12 c.c.), one-half of the total volume given being injected into each buttock. This procedure was carried out with the patient recumbent, extremities uncovered, in a room temperature of 70 to 75° F. Variation in room temperature during the test was negligible. Where possible, a basal state was employed. A blood pressure cuff was applied to the arm and one or more determinations of blood pressure and pulse determinations were made. Utilizing the same arm, and the cuff for a tourniquet, tetraethylammonium bromide 10 per cent was slowly injected, the rate and volume of injection being governed by changes in pulse volume and the general systemic reaction of the patient. An acceleration of pulse rate was usually noted, but only significant changes in pulse volume were taken as a guide to cease or delay further injection of the drug. Under no circumstance were more than 5 c.c. intravenously administered.

The intramuscular route was employed only in cases under observation in the hospital. The effects of the intramuscular injection of tetraethylammonium bromide usually lasted six to eight hours.

The intravenous injection produces a metallic taste in the mouth in 15 to 20 seconds on most occasions. Thereafter, the patient notices a "cool sensation" in the hands and feet which is followed within five minutes by a perceptible increase in skin temperature. There is an incomplete dilation of the pupil with some loss of accommodation. Shortly after the injection (approximately one minute), systolic and diastolic blood pressures tend to fall, particularly in the hypertensive patient. This fall in blood pressure is accompanied by an increase in pulse rate to between 90 and 120 beats per minute. Sweating, if present, ceases and the patient may become aware of a dry mouth. The vasoconstrictor gradient present in the extremities is largely abolished, so that toe and thigh temperatures are equalized (Figs. 1 and 2). The blood pressure gradually increases to the initial level although postural hypotension may exist for 15 to 60 minutes.

RESULTS OF BLOCKING THE AUTONOMIC GANGLIA WITH TETRAETHYLAMMONIUM BROMIDE

1. *Functional Vascular Disorders.*—Some sixteen patients were studied with functional angiospastic disorders. Eight of these patients had Raynaud's phenomena alone or in association with other disorders; four patients had functional disorders such as acrocyanosis and livedo reticularis, and four patients had Raynaud's phenomena in association with scleroderma.

In this group, the functional response to tetraethylammonium was usually quite marked, a substantial rise in skin temperature and alleviation of at least a part of the clinical picture being the usual sequelae (Fig. 1).

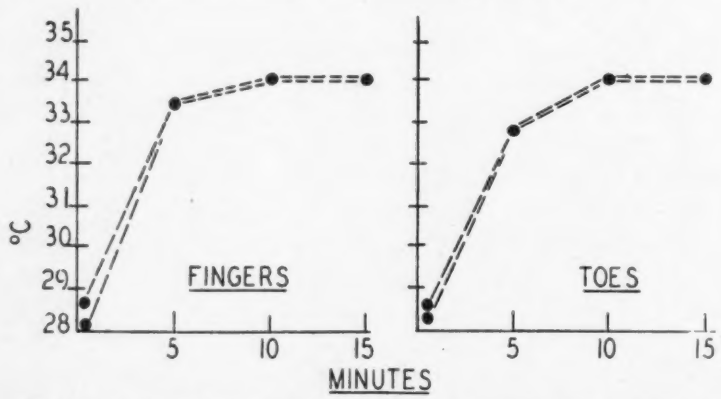

Fig. 1.—Peripheral skin temperature response in a patient with Raynaud's phenomena following the intravenous injection of 500 mg. tetraethylammonium bromide. Patient subsequently developed disseminated lupus. Smoking did not alter the skin temperature readings.

There was a marked variation in the duration of the response to autonomic ganglia blockade in this group with functional disorders. For the most part, the drug served three useful purposes in these patients: (1) it obviated the necessity of single or multiple paravertebral blocks, particularly for the upper

extremity; (2) it was helpful in establishing the presence of a functional vascular component, particularly in the patients with scleroderma; (3) it was exceedingly helpful in aiding the establishment of a diagnosis.

The following case report is that of a patient with fulminating Raynaud's disease, who received intensive daily therapy in an attempt to ameliorate impending gangrene.

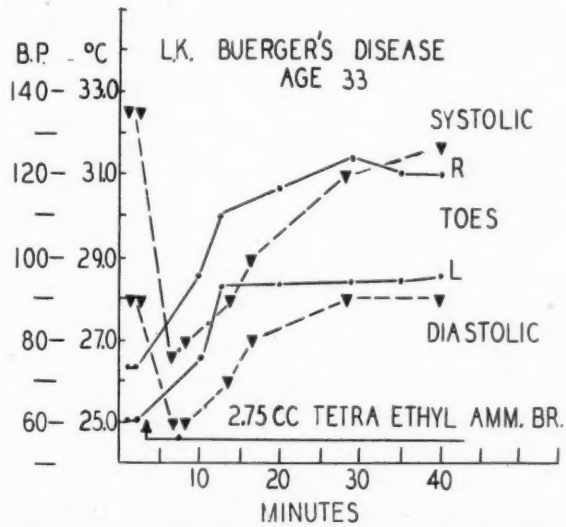

Fig. 2.—The effect on blood pressure and peripheral skin temperature of blocking the autonomic ganglia with 275 mg. of tetraethylammonium bromide in a patient with thromboangiitis obliterans. The left leg had advanced occlusive changes. Superficial phlebitis was present in the right leg.

CASE REPORT

M. T. (No. 236753), aged 30 years, a white woman, was admitted May 21, 1946, with the chief complaint of cold, blue, painful fingers and superficial gangrene of distal phalanges of the fourth right and third left fingers of nine days' duration. There were no previous similar attacks. On May 12, 1946, there was an onset of blanching (syncope), numbness and tingling, cyanosis and paroxysmal attacks of severe pain in symmetrical fingers of both hands. A strong suspicion of initial psychic trauma in the history was entertained but could not be elicited from the patient. There was a known fluctuation of blood pressure with the patient's paroxysms of pain. No petechial manifestations had been observed.

Examination revealed a blood pressure of 112/70. The patient was a highly excited woman in obvious distress. The hands were cold, cyanotic, and moist, and reticular blotching extended onto the forearms. The phalangeal joint areas were mildly edematous with some restriction of motion (35 per cent). There was superficial gangrene of the fourth right and third left finger tips. There was marked cyanosis of the entire distal two phalanges of the index and fifth fingers bilaterally.

Tetraethylammonium bromide, 500 mg. intravenously, was administered with the following results: the cyanotic areas became red and warm. The patient was able to flex the fingers without restriction in approximately fifteen minutes. The reticular mottling disappeared. Skin temperature changes were as follows:

	RIGHT		LEFT	
Thumb	31.4-33.0° C.		29.8-32.0° C.	
Index	30.5-33.0° C.		28.5-31.5° C.	
Third	31.5-33.5° C.		29.0-29.0° C.	(gangrene)
Fourth	29.2-30.4° C.	(gangrene)	30.4-33.0° C.	
Fifth	28.9-30.0° C.		30.2-32.8° C.	

Chest roentgenograms, detailed views of the cervical spine, electrocardiogram, blood cultures, blood studies, etc., were negative with the exception of a previously known rotoscoliosis.

Repeated daily intravenous injections of tetraethylammonium were given to produce a sympathetic block, with gradual abatement of the fulminating Raynaud's syndrome, improvement in color, relief of pain, and arrest of further gangrenous changes. Bilateral dorsal sympathectomy was then performed on May 31, 1946, with the hope that further recurrences would be less likely to occur. Convalescence was uneventful.

2. *Organic Obstructive Vascular Lesions.*—We have had the opportunity of studying the effects of tetraethylammonium bromide in some eighteen patients with thromboangiitis obliterans and some fifty-five patients with all stages of peripheral arteriosclerosis obliterans. Of the patients with Buerger's disease, eleven have been treated conservatively over periods varying from two weeks to six months; three patients have had sympathectomy performed, one patient had a supracondylar amputation for moist gangrene (patient untreated except for diagnostic test), and three patients received only a single injection for the purpose of producing a sympathetic block. Of these three latter cases, all will be carried on a conservative regimen. Of the eleven patients treated conservatively including repeated sympathetic blocks by tetraethylammonium, five are symptom free including practical absence of previously existing intermittent claudication. Exercise tolerance has improved in all of this group. In the remaining nine patients in the group being treated conservatively, there has been a similar satisfactory decrudescence of clinical signs and symptoms, but this group has had only a relatively brief period of treatment (four to eight weeks). Three patients with thromboangiitis obliterans presented themselves in the clinic initially with active superficial migratory phlebitis. These patients were hospitalized for brief periods (three days) during which time they received either repeated autonomic ganglion blockade (intravenous and intramuscular) daily, or daily blocks by the intravenous route. In all instances there appeared to be a satisfactory subsidence of the active inflammatory process. It is realized, of course, that similar changes might have occurred during bed rest without additional therapy. It is interesting to note, however, that none of these patients in this group have had a recurrence of the phlebitis to date (Fig. 2).

TABLE II. CONTROL OF PAIN AND PREDICTED RESPONSE TO SYMPATHECTOMY
L. RU., AGED 36, BUERGER'S DISEASE*

TIME	DOSE	DURATION RELIEF	HOURS
2:30 P.M.	200 mg. i.v.	6:45 P.M.	3+
12:10 A.M.	300 mg. i.v.	1:30 A.M.	1+
2:25 P.M.	250 mg. i.v.	8:00 A.M.	17+

2-Stage Bilateral Lumbar Sympathectomy and Right Sural Neurectomy

	RESPONSE				
TETRAETHYLAMMONIUM BROMIDE			SYMPATHECTOMY		
	° C.			° C.	
Thigh	34.0	34.0	Thigh	32.0	32.4
Calf	33.2	32.5	Calf	32.3	31.4
Toe	30.0	30.0	Toe	30.1	30.1

Complete Pain Relief

*Control of pain and predicted thermal response to sympathectomy in a patient with thromboangiitis obliterans and severe intractable pedal pain of two years' duration, especially nocturnal and predominantly on the right. The lower columns of figures correspond to right and left thigh, calf, and toes, respectively.

The following case histories are examples of the response to tetraethylammonium bromide exhibited by three patients with thromboangiitis obliterans. One of these patients has been followed for eight months (C.N.), one for 5 months (L. Ro.) and one patient (L. Ru.) had a bilateral sympathectomy performed (Table II).

CASE REPORTS

L. Ro. (No. 469585), aged 29 years, Hungarian-Jew, was admitted March 22, 1946, with a two months' history of intermittent claudication, numbness and tingling in right foot and calf, and nocturnal foot pain. The patient had smoked one package of cigarettes daily for twelve years. Examination revealed slight pallor of the right foot on elevation. Vessel pulsations were present (weakly) peripherally. The right foot was colder than the left and a marked temperature gradient was measurable. Tetraethylammonium bromide, 500 mg., was injected intravenously, following which the numbness and tingling promptly disappeared (fifteen minutes). There was a 5° C. rise in skin temperature of the toes. He returned April 5, 1946, stating that pain has ceased and the intermittent claudication was less severe. He had ceased smoking. Thereafter at weekly intervals he received autonomic ganglia blocks with tetraethylammonium bromide and continued to show progressive improvement. A right paravertebral sympathetic block with procaine demonstrated an excellent functional response comparable to that produced by the drug. On May 11, 1946, claudication had practically ceased and the patient was under full-time employment. A total of seven sympathetic blocks at weekly intervals using tetraethylammonium was given. This represented a total dose of 3,500 mg. The patient has remained symptom free on repeated examinations.

C. N. (No. 187333), aged 43 years, a white man, was admitted Feb. 4, 1946, with a six-year history of recurrent superficial migratory phlebitis of both legs. The patient had experienced progressive intermittent claudication for four years. Cold weather aggravated the complaints. Nocturnal pain was frequently present. Examination revealed typical acute saphenous phlebitis on the right calf. Posterior tibial and dorsalis pedis pulses were absent bilaterally. X-ray examination of the legs and feet revealed no arterial calcification. Tetraethylammonium bromide, 500 mg. intravenously, produced a 4° C. rise in skin temperature of the toes and the patient stated that following this procedure, the legs felt normal for the first time in years. He returned Feb. 7, 1946, stating that the claudication had greatly improved and the nocturnal pain had remained absent. The phlebitic process showed evidence of subsidence. He received 1.2 Gm. of the drug intramuscularly and returned on Feb. 8, 1946. At this time, pulses were weakly palpable bilaterally at the ankle. He again received 1.0 Gm. tetraethylammonium intramuscularly and was instructed to return in two weeks at which time the therapy was repeated. The only residual of the phlebitic process was a cord-like area of nonpainful induration. He returned one month later on April 4, 1946, able to walk three blocks without claudication. This was farther than he had been able to walk in several years. The total dose of tetraethylammonium administered was 4,700 mg.

Peripheral arteriosclerosis obliterans: Fifty-five patients with clinical signs and symptoms of peripheral arteriosclerosis obliterans have been studied, utilizing tetraethylammonium bromide as a diagnostic, prognostic, and therapeutic measure. The drug has proved useful in two respects in these patients: (1) aiding in the control of nocturnal pain, and (2) as an index of the possible benefits that might be derived from a lumbar sympathectomy.*

Early in the course of study of tetraethylammonium bromide, it was noted that in some of the patients with arteriosclerosis obliterans, who were complaining bitterly of nocturnal pain, that relief was experienced following the intra-

*Subject of separate report.

venous or intramuscular injection of tetraethylammonium bromide. This relief occurred whether or not a functional component was demonstrable, that is, the relief occurred despite the absence or presence of vasospasm, and the nocturnal pain returned only if the injections of the drug were discontinued. Several of these patients claimed relief of pain superior to that obtained from morphine.

The following case history is illustrative of the use of tetraethylammonium in the study and therapy of peripheral arteriosclerosis obliterans.

CASE REPORT

H. C. (No. 585004), aged 62 years, a white man, was admitted Feb. 4, 1946, with a nine-month history of intermittent claudication in the right calf. Several months previous to admission, a saphenous ligation had been performed elsewhere for supposed varices. Following this procedure, pain and discoloration of the foot appeared and a 4 by 4 inch area of dry gangrene on the dorsum of the foot subsequently developed. There was a three months' history of constant pain in this foot, especially at night. Examination revealed far-advanced occlusive peripheral arteriosclerosis. Tetraethylammonium bromide intravenously demonstrated a small functional component to be present, a 1.5° C. rise in skin temperature being the maximal response. The patient experienced relief of the nocturnal pain following the administration of the drug, and was accordingly treated with repeated intramuscular injections of tetraethylammonium bromide, 5,000 mg. given in divided doses. When this therapy was withdrawn, the nocturnal pain recurred. No improvement in the gangrenous slough occurred and, accordingly, a right supracondylar amputation was carried out on Feb. 25, 1946. He recovered satisfactorily. It was felt that the wisest procedure, as a prophylactic measure, would be to perform a left lumbar sympathectomy as a protective measure for the remaining weight-bearing extremity. This was carried out on March 7, 1946. Follow-up report on June 7, 1946, showed the patient to be in good condition. The predicted thermal response to sympathectomy as judged by response to tetraethylammonium bromide was exact.

3. *Causalgic Disorders and Reflex Sympathetic Dystrophies.*—Some seventeen patients with a diagnosis of causalgia, posttraumatic edema, or reflex sympathetic dystrophy have been studied utilizing tetraethylammonium bromide. The choice of terminology for diagnosis in some of these patients was quite difficult. These disorders occurred as the result of old fractures with prolonged immobilization, gunshot wounds with associated nerve palsy, delayed postoperative edema of the arm with and without intractable pain, fibrositis, periarthritis and Sudeck's atrophy, cervical rib with vasospasm, healed chronic infection of the fascial spaces, postimmersion and trench foot sequelae, old trauma, etc.

The injection of tetraethylammonium in these patients served three useful purposes: (1) it usually afforded temporary and at times sustained relief of pain; (2) it aided in establishing the diagnosis of reflex dystrophy; (3) it was highly effective as a therapeutic measure in selected cases.

The following case report is illustrative of the use of tetraethylammonium bromide in producing autonomic ganglion blockade in this group of patients.

CASE REPORT

D. L. (No. 588735), aged 54 years, a white woman, was admitted April 29, 1946, with a history of having sustained a fracture of the left humerus on Nov. 17, 1945, which had been treated with a hanging cast. Examination revealed a typical reflex sympathetic dystrophy, periarticular fibrositis, and Sudeck's type atrophy with a painful, hypersensitive left upper

extremity. The left hand was cool and moist with periarthritic changes and moderate edema. Injection intravenously of 350 mg. tetraethylammonium bromide produced an excellent autonomic block with a 4° C. rise in temperature of the digits. She was again seen and treated on April 30, 1946, there having been some improvement in range of motion of the fingers. On May 1, 1946, a third injection was given and examination at this time revealed a practically normal range of motion of all joints in the left upper extremity. All pain had disappeared with exception of pain in the shoulder girdle. Despite this, the patient was able to elevate the hand above the head for the first time in months. On May 2, 1946, a fourth injection of the drug was given and the patient reported complete freedom from pain. Thereafter, she was followed at frequent intervals until May 28, 1946, at which time improvement was felt to be maximal. A total dose of 7,200 mg. of tetraethylammonium bromide was given this patient.

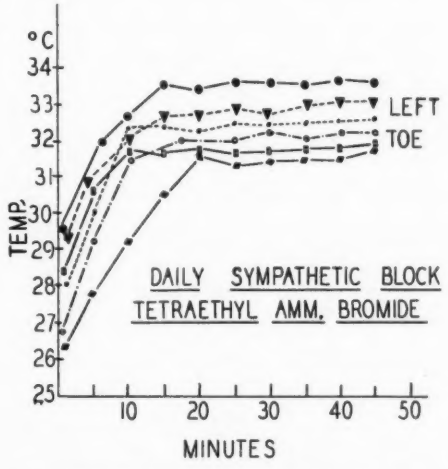

Fig. 3 (T. E.).—Response to daily autonomic ganglion blockade in a patient with progressive iliofemoral thrombophlebitis of the left lower extremity.

4. *Thrombophlebitis.*—Nine patients with superficial or deep thrombophlebitis have been treated with tetraethylammonium. All nine of these exhibited vasospasm in association with the primary disorder prior to treatment (hyperhidrosis, pain, mild cyanosis, coldness, demonstrable vasoconstriction). Six of the nine patients had either acute or chronic deep femoral thrombophlebitis. The three remaining patients had migratory phlebitis in association with thromboangiitis obliterans.

Tetraethylammonium proved useful in two respects in this group of cases, (1) as a measure capable of releasing vasospasm by blocking the autonomic ganglia, and (2) as a therapeutic measure in the acute or active cases wherein daily blocks proved advantageous as a supplementary measure in therapy. The duration of effects was surprisingly variable, some patients reporting a period of several days in which the extremity remained warm and painless, while other patients experienced relief of symptoms for only a few hours.

The following case report is illustrative of the most striking response to tetraethylammonium in the group of patients with thrombophlebitis (Fig. 3).

CASE REPORT

T. E. (No. 584769), aged 31 years, a white man, was admitted Jan. 6, 1946, with a history of having been in an automobile accident two months previously, at which time he

traumatized the lateral aspect of the left leg. Roentgenograms were reported as negative. Two weeks after the accident, the patient experienced sudden severe chest pain of a pleuritic nature followed shortly by prune juice sputum. This was diagnosed elsewhere as pneumonia despite a swollen, painful, left lower extremity. He had also experienced chills and fever. He was treated at that time with paravertebral sympathetic blocks, and had gradual abatement of the acute process. Upon returning home (Michigan), he experienced an acute exacerbation of the thrombophlebitic process with swelling, pain, and fever. Examination on Jan. 6, 1946, revealed a moderately ill white man with gross ligament. Homan's sign was positive. There was calf and groin tenderness. Collateral venous tributaries were evident. The patient was hospitalized and received daily intravenous and intramuscular injections of tetraethylammonium bromide (Fig. 3). There was rapid subsidence of the edema and within ten days the patient was afebrile, ambulatory, and free of significant edema. He was discharged on supportive measures. Careful bimonthly follow-up reports state that the patient has remained asymptomatic and that he does not have significant edema.

UTILIZATION AS AN OUTPATIENT PROCEDURE

The intravenous injection of tetraethylammonium bromide to produce autonomic blockade has been utilized daily as an outpatient procedure for the past eight months. Following treatment, the patient is maintained in a horizontal position for at least 15 to 30 minutes. At the end of this time he is allowed to sit up and then stand up. If no dizziness or syncope occurs, or if postural hypotension is not marked, he is allowed to walk about the clinic for a few minutes and is instructed to lie down should he experience unpleasant symptoms. No emergency hospitalization following the administration of this drug has been necessitated at any time. The patient is asked to refrain from driving his car for one to two hours because of loss of accommodation. The patient is usually unaware of any visual impairment. Adrenalin is specific in counteracting any untoward symptoms.

TOXIC EFFECTS

In the doses used in this study and in the patients reported here, no significant toxic effects were noted. In other cases reported elsewhere,[8] complications of the injection were experienced. Some patients with very high blood pressure experienced a state of peripheral circulatory collapse following the intravenous injection which was quite transient in character and which responded to epinephrine. Other patients had developed a state of dyspnea similar to that observed in hysterical hyperventilation. In a few patients the sensation of weakness, fatigue, and lightheadedness was very pronounced. They appear to experience difficulty with muscle movement, though when tested there was no loss of strength or change in reflexes. The drug has been administered more than 1,000 times to more than 500 patients in the doses indicated with very few alarming reactions.

SUMMARY

1. Clinical experience with tetraethylammonium (bromide or choride) has demonstrated its efficiency in producing blockade of the autonomic ganglia to a degree comparable to that obtained following the usually accepted methods of producing a sympathetic block.

2. A large and varied series of peripheral vascular and allied disorders have been studied utilizing this drug as a method of producing either a temporary or prolonged sympathetic block to improve circulation or ameliorate pain of circulatory origin. This drug has proved satisfactory in producing both of these desired results.

REFERENCES

1. Ochsner, A., and DeBakey, M.: Peripheral Vascular Disease. A Critical Survey of Its Conservative and Radical Treatment, Surg., Gynec. & Obst. **70**: 1058-1072, 1940.
2. Acheson, G. H., and Moe, G. K.: Some Effects of Tetraethylammonium on the Mammalian Heart, J. Pharmacol. and Exper. Therap. **84**: 189-195, 1945.
3. Acheson, G. H., and Moe, G. K.: The Action of Tetraethylammonium Ion on the Mammalian Circulation, J. Pharmacol. and Exper. Therap. **87**: 220, 1946.
4. Acheson, G. H., and Pereira, S.: The Blocking Effect of Tetraethylammonium Ion on the Superior Cervical Ganglion of the Cat, J. Pharmacol. and Exper. Therap. **87**: 273, 1946.
5. Lyons, R. H., Moe, G. K., Campbell, K. N., Hoobler, S. W., Neligh, R. B., Berry, R. L., and Rennich, B.: The Effects of Blockade of the Autonomic Ganglia in Man. Preliminary Observations on the Use of Tetraethylammonium Bromide, Univ. Hosp. Bull., Ann Arbor **12**: 33, 1946.
6. Lyons, R. H., Moe, G. K., Neligh, R. B., Hoobler, S. W., Campbell, K. N., Berry, R. L., and Rennich, B.: The Effects of Blockade of the Autonomic Ganglia in Man With Tetraethylammonium. Preliminary Observations on Its Clinical Application, Am. J. M. Sc. In press.
7. Ochsner, A., and DeBakey, M.: Therapeutic Consideration of Thrombophlebitis and Phlebothrombosis, New England J. Med. **225**: 207-227, 1941.
8. Scott, W. J. M., and Morton, J. J.: Sympathetic Activity in Certain Diseases, Especially Those of the Peripheral Circulation, Arch. Int. Med. **48**: 1065, 1931.
9. White, J. C.: Diagnostic Blocking of the Sympathetic Nerves to Extremities With Procaine, J. A. M. A. **94**: 1382-1388, 1930.
10. Trimble, R., Cheney, W. S., and Moses, W. R.: The Operative Attack on Organic Peripheral Vascular Disease, SURGERY **15**: 655-678, 1944.
11. Leriche, R., and Fontaine, R.: Experimental and Clinical Contribution to the Question of Innervation of the Blood Vessels, Surg., Gynec. & Obst. **47**: 631-643, 1928.
12. Grimson, K. S.: Sympathectomy and the Circulation—Anatomic and Physiologic Considerations and Early and Late Limitations, SURGERY **19**: 277-298, 1946.
13. Evans, J. A.: Reflex Sympathetic Dystrophy, Surg., Gynec. & Obst. **82**: 36-43, 1946.
14. Coller, F. A., and Maddock, W. G.: The Function of Peripheral Vasoconstriction, Ann. Surg. **100**: 983-992, 1934.
15. Ochsner, A.: Indications and Technique for Interruption of Impulses Traversing the Lumbar Sympathetic Ganglia, S. Clin. North America, pp. 1318-1334, 1943.

TREATMENT OF NONUNION OF THE CARPAL NAVICULAR BONE

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TREATMENT of nonunion of a fractured carpal navicular bone directed primarily to alleviate recurrent pains and swelling of the wrist is far from a solved problem, as is evidenced by lack of uniform good end results. The methods of treatment presently in use are those of excision of part or all of the fractured navicular bone, excision and replacement by vitallium replica, drilling, or bone grafting of the segments.[1] The latter procedures, namely, drilling or bone grafting, are designed to revascularize the necrotic or partly necrotic bone, the sclerotic borders, or the intervening fibrous barrier at the site of nonunion by granulation tissue derived in part from the contiguous living portion of the navicular bone. The success of either one of these two surgical methods depends primarily on the potential source of blood supply and the osteogenic tissue derived from the contiguous living fragment or fragments of the carpal navicular bone. When the blood supply from the contiguous fragments is inadequate, and this occasionally occurs, nonunion may result in spite of these surgical interventions. Excision of parts or of the entire fractured navicular bone results in some instances in weakness, pain, and loss of function in the wrist. This particular surgical treatment is, therefore, not generally advised.

Based on the observation that bone formation occurs frequently at the site of nonunion of a fractured femoral neck after a subtrochanteric osteotomy, a procedure employing a parallel idea was used in selected cases of nonunion of the fractured carpal navicular bone. Instead of an osteotomy, an arthrodesis between the fractured navicular bone and the capitate bone and curettement at the site of nonunion were performed in an attempt to obtain bony obliteration of the navicular capitate joint and simultaneous healing of the navicular bone (Fig. 1). This procedure was done in four patients, in three of whom there was evident nonunion of the carpal navicular bone complicated by either relative sclerosis, resorption, or marginal exostoses and recurrent local pain and swelling. In the fourth patient, in an instance of simultaneous fractures of the right and left navicular bones, this procedure was performed in an attempt to abort a rapid progressive resorption and sclerosis of the surfaces at the site of non-union of one of the fractured navicular bones.

Three of these four patients had suffered from mild trauma to their wrists, ten months, two years, and four years before, respectively. None had received any previous medical attention for these injuries. With the pursuit of light work in civilian life, these three patients had only occasional attacks of local pain and swelling. After they had performed several months of routine military duties, it was noted that their wrists had become chronically enlarged and painful. In fact, they all reached a stage where they were unable to do any type

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of work without experiencing pain in the carpal region. Furthermore, examination revealed that the normal landmarks of the wrists were obliterated by effusion and that tenderness was present on pressure over the fractured navicular bones. The fourth patient suffered from simultaneous fractures of the right and left carpal navicular bones following an injury sustained in a troop football game. In this case, immobilization of the right and left forearms, wrists, and thumbs in plaster of Paris bandages was followed for five successive months. This had resulted in complete healing of the right navicular bone and progressive resorption at the site of fracture with resultant sclerosis and nonunion of the left navicular bone. In this case and in the three previously mentioned, arthrodesis was performed between the navicular and capitate bones.

Fig. 1.

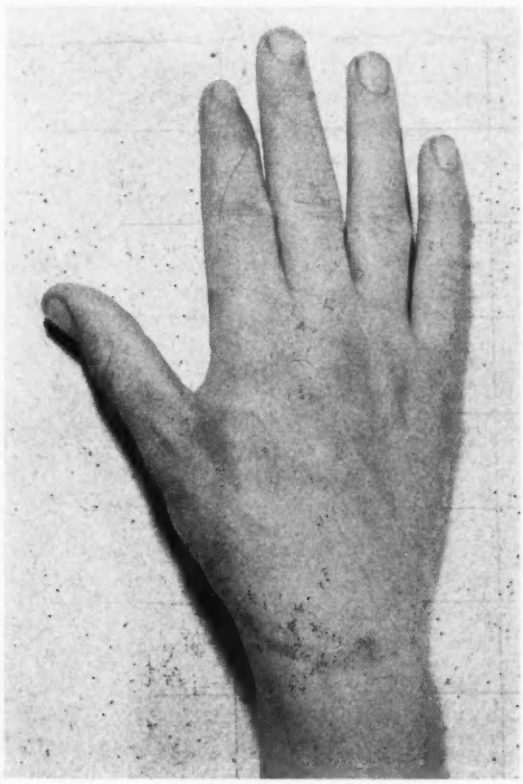

Fig. 2.

Fig. 1.—Diagram of carpal bones of wrist. *N* is the fractured navicular bone; *C* is the capitate bone. The hatch lines indicate the site for the curettement and implantation of bone slivers.

Fig. 2.—Note scar on dorsum of hand as result of operation. This patient had an arthrodesis between an old ununited fracture of the navicular and capitate bones.

Technique of Operation.—A horizontal incision measuring about two inches in length was made on the dorsum of the wrist in the region of the styloid process of the radius to a point in the vicinity of the distal radioulnar articulation (Fig. 2). The long extensor tendon to the thumb and the common extensor tendons of the fingers were exposed and retracted to either side of the wound. The dorsal branch of the radial nerve was isolated and retracted. The

dorsal carpal ligament was incised in a cruciate fashion close to the insertion of the extensor carpi radialis brevis tendon in order to expose the joint space between the navicular and capitate bones. The contiguous articular cartilages of these two bones were removed to expose their subchondral regions. The site of nonunion of the navicular bone was thoroughly curetted to remove the sclerotic bone and the fibrous or granulation tissue. Slivers removed from the body of the capitate bone were placed in the navicular capitate joint space and into the curetted site of nonunion. The dorsal ligament of the wrist was loosely coapted and the tendons were reposited into their respective sheaths. The latter were closed with fine catgut and the skin was sutured with fine steel wire. A plaster of Paris bandage was applied to the forearm, wrist, and hand to the level of the interphalangeal joint of the thumb and necks of the metacarpals of the fingers holding the hand in 20 degrees of dorsiflexion and in maximal pronation. The plaster of Paris bandage was removed and reapplied every six weeks for a period ranging from five to six months following the operation.*

A. *B.*

Fig. 3.—*A*, Radiograph revealing nonunion of the navicular bone with resorption of its surfaces at the fracture site (nonunion present for two years). *B*, Radiograph taken six months after the arthrodesis; note healing of the fractured navicular bone and fusion to the capitate bone.

Pre- and Postoperative Radiographic Findings.—Preoperative radiographic examinations of the wrists of the four patients revealed definite evidence of nonunion of the navicular bone complicated by either relative increase in density of the proximal fragment, marked resorption or sclerosis of the margins at the

*It is of interest that in 1924 Thornton described a case of subluxation of the capitate bone which was treated by resection of its base and arthrodesis to its contiguous carpal bones.[2] No mention was made of treatment of a specific case of an ununited fractured navicular bone by this method.

site of nonunion, or the presence of marginal osteophytes. In three instances the postoperative radiographic examination revealed beginning union and fusion of the navicular bone to the capitate bone approximately four months after the surgical intervention. Radiographs taken from six to twelve months after the operation showed the presence of bone in the previously noted rarified lesions as well as demineralization of the sclerotic foci in the navicular bone. Healing of the fractured navicular bone as well as fusion of these fragments to the capitate bone was definitely present in the three subjects in periods varying from six to twelve months after the operation (Fig. 3). In one case in which an interval of four years of nonunion existed prior to the operation, bony healing of the fractured navicular bone was still incomplete eight months after the surgical intervention.

Pathologic Findings.—Microscopic examination of the tissue removed during the operative intervention revealed that the bone obtained from the dense or sclerotic areas was for the most part necrotic and that the rarified areas (pseudocysts) were filled with loose granulation tissue. Portions of the articular cartilages which were removed in the vicinity of the nonunion presented definite evidence of fibrillation and degeneration. In addition, in one instance irregular proliferation of new bone and cartilage was also observed which indicated the presence of a marginal osteophyte. Capsular tissue obtained from the navicular capitate articulation showed definite evidence of increased vascularization and hypercellularity of the synovial lining.

Follow-Up Observation.—Follow-up examinations of the four patients from eight to twelve months after the arthrodesing operation revealed that the "annoying" pain and swelling probably due to a local synovitis which existed prior to the surgical intervention was now absent. Although the range of motion in the wrists was to a certain extent lessened as a result of the operation, the resultant power of the affected hands was definitely increased. In fact, these four patients are now doing some type of useful work in the Armed Forces where previously they were compelled because of local pain and swelling to limit the use of their hands (See Table I).

TABLE I. RANGE OF MOTION AT THE WRISTS BEFORE AND SIX MONTHS AFTER OPERATION

	PREOPERATIVE RANGE OF MOTION OF HAND (IN DEGREES)					POSTOPERATIVE RANGE OF MOTION OF HAND (IN DEGREES)				
CASE NUMBER	ACTIVE DORSI FLEXION	PASSIVE DORSI FLEXION	ACTIVE PALMAR FLEXION	PASSIVE PALMAR FLEXION	TOTAL RADIAL AND ULNAR FLEXION	ACTIVE DORSI FLEXION	PASSIVE DORSI FLEXION	ACTIVE PALMAR FLEXION	PASSIVE PALMAR FLEXION	TOTAL RADIAL AND ULNAR FLEXION
1. Nonunion for 6 mo. (bilateral fractures)	40	45	35	35	35	40	60	35	35	35
2. Nonunion for 10 mo.	25	25	60	50	45	30	30	25	25	20
3. Nonunion for 2 yr.	45	45	50	55	35	20	35	20	20	25
4. Nonunion for 4 yr.	10	10	40	45	25	20	20	30	30	20

DISCUSSION

The suggested procedure is not indicated in every case of nonunion of a fractured carpal navicular bone. In most instances multiple drilling of the fragments or the insertion of an autogenous bone graft heals the nonunion of the navicular bone. Neither one of these two methods, however, has any immediate effect on an existing traumatic arthritis in the intercarpal region. Arthrodesis between the navicular and capitate bones is recommended in those instances where there is extensive resorption or sclerosis of one or both fragments or when marginal osteophytes about the navicular or capitate bones are observed, especially when complicated by recurrent effusion and pain in the carpal region. Intercarpal arthrodesis is also applicable in nonunion or old subluxations of any of the other carpal bones where similar clinical conditions are present.

The forementioned procedure permits the opening of numerous avenues into the contiguous marrow spaces of relatively normal bone for a new and additional source of blood supply. This enhances "creeping replacement," transformation of the pathologic bone to a viable state, and aids in the healing of the nonunion.

SUMMARY AND CONCLUSION

In each of three cases of nonunion of the navicular bone complicated by either marked sclerosis, resorption, or marginal osteophytes of the navicular bone, as well as by pain and local effusion, an arthrodesis was performed between the fractured carpal navicular bone and the capitate bone. In the fourth instance of bilateral fractures of the navicular bone this procedure was done to abort a progressive resorption of one of these bones. In three of these four patients healing of the fractured navicular bone and bony obliteration of the navicular capitate articulation were noted from six to twelve months after the operation. In one instance in which there was nonunion existent for four years prior to the operation, incomplete bony healing was still noted eight months after the operation. It is interesting that follow-up examination from six to twelve months after the operation disclosed that there was an absence of swelling and pain in the four wrists even after repeated use of the hands. Some loss of motion was observed in each of the four wrists as a result of the surgical intervention. This was, however, compensated by the definite gain of power in the affected wrists and hands.

REFERENCES

1. Davidson, Arthur, J., and Horwitz, M. Thomas: An Evaluation of Excision in the Treatment of Ununited Fracture of the Carpal Scaphoid (Navicular) Bone, Ann. Surg. **108**: 291, 1938.
   Murray, G.: Bone Graft for Non-union of the Carpal Scaphoid, Surg., Gynec. & Obst. **60**: 529, 1935.
   Waugh, R. L., and Reuling, L.: Ununited Fractures of the Carpal Scaphoid, Am. J. Surg. **67**: 184, 1945.
2. Thornton, Lawson: Old Dislocation of Os Magnum, South. M. J. **17**: 430, 1924.

A NEW METHOD OF BONE PLATING

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THE management of a simple fracture of the shaft of bone is time-tested and universally accepted. In essence this consists of approximating the ends of the fragments and then immobilizing the limb. When open reduction is indicated and a plate is then required for continued apposition of fragments, the treatment is definitely found wanting. The rational in using a plate is to appose the two broken sections of the shaft and to immobilize them. Unfortunately, this has not been accomplished. The fragments have been apposed but immobilization has been impossible with any plate used in the past. Even by causing some degree of impaction the play of the broken ends of bone upon one another eventually results in a hiatus or space between the apposed fragments and healing is consequently delayed. This knowledge has made immobilization of the broken limb, through plaster or some other means, mandatory following the application of a plate. Immobilization to be effective must include the joints on *both ends* of the fracture. This in turn, over a period of time, results in atrophy of muscle, decalcification of bone, and stiffness of the joints. In fact the disuse atrophy with its concommitant discomfort may be more of a problem than the original fracture.

I have devised an "assembly" consisting of two metal plates which appose the fragments of a bone shaft and immobilize them. In addition, the application in the hands of a qualified surgeon is simple and does not require any complicated or expensive equipment. The effectiveness of this "assembly" is such that no subsequent immobilization in plaster is necessary and rapid weight-bearing is permitted.

These exemplary features were discussed in a previous communication.† However, some noteworthy changes have since been made in the nuts and bolts which fix the immobilizing plates. This has permitted a simplification of the operation and has reduced the operative time to such an extent that I feel justified in presenting these improvements in this paper.

The appearance of the Wenger plate assembly can be seen in Figs. 1 to 7.

The operative technique used in applying the assembly consists of making an incision at the site of the fracture, and then aligning the fracture in anatomic reduction (see Fig. 3). While this is held in position by an assistant, the front plate (slotted plate) is placed across the site of the fracture on the bone surface nearest the operator. Four bolts are inserted into the holes and nuts are fitted onto both sides of each bolt (see Fig. 4). The two outer bolts are

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†Wenger, H. Leslie: Shaft Fracture Immobilization Without Plaster, Am. J. Surg. 66: 382-383, 1944.

then securely tightened. The two inner bolts are left loose until the back or notched plate is slipped into position under the nuts (see Figs. 5 and 6).

When the notched plate is inserted under the two inner nuts, these latter are tightened with the wrench and the immobilization is complete. The construction of the notched plate permits compensation for inaccuracies in the position of the bolt holes.

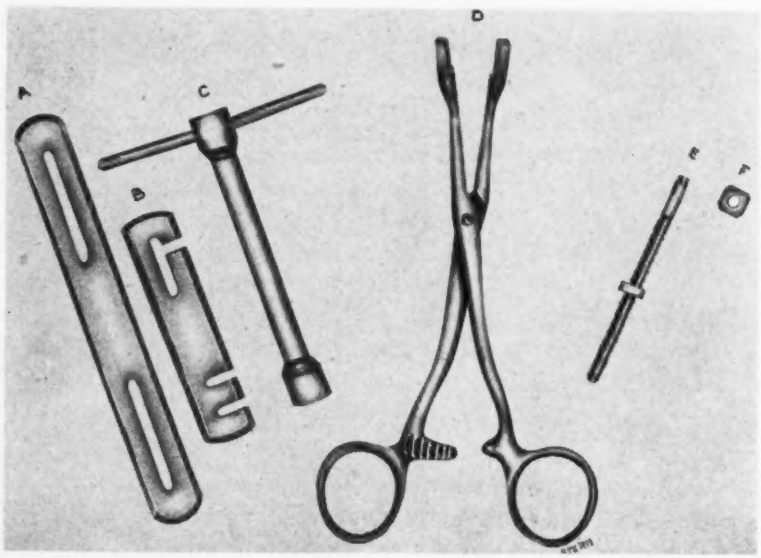


Fig. 1.—*A* and *B* are paired vitallium plates applied on opposite surfaces of the fractured bone. The larger plate (*A*) is known as the slotted plate and the smaller (*B*) as the notched plate. *C* is the wrench for tightening nuts, *D* is the clamp which holds the opposite nut firm so that the bolt does not turn, and *E* is the bolt which is designed so that threads are at both ends and the threads on the far side of the bolt limit the nut on the bolt.

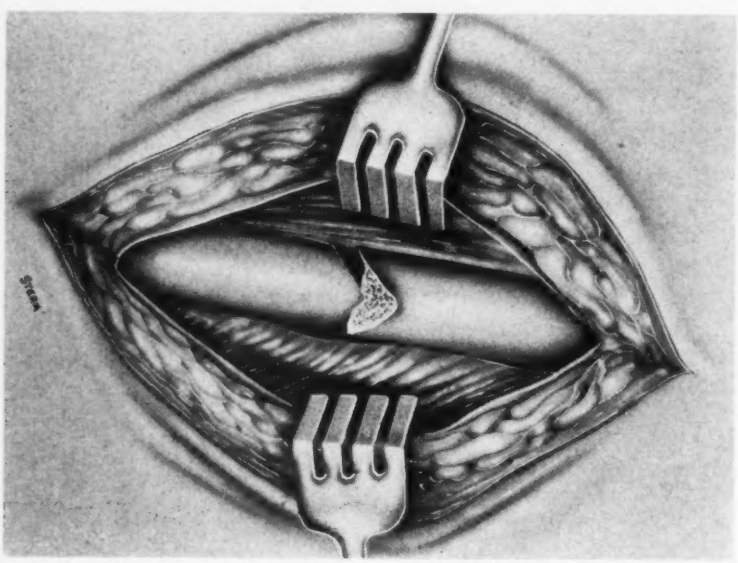


Fig. 2.—A shaft fracture with an operative exposure. The following Figs. 3 to 7 demonstrate the method of application of the assembly in situ of this fracture.

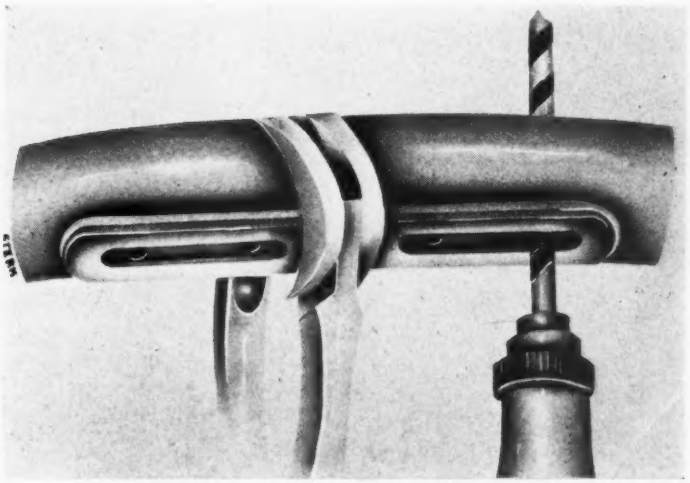
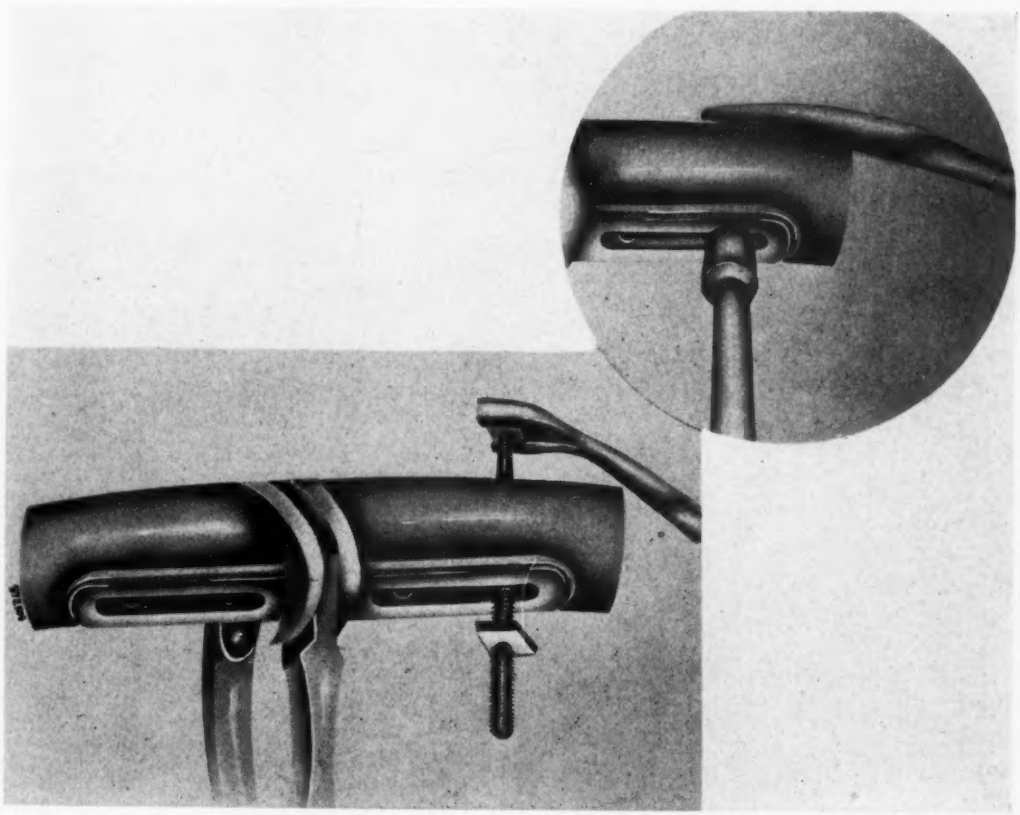


Fig. 3.—The fracture is reduced and held with a bone clamp. The slotted plate is in position and the four drill holes are in the process of being made.



A. *B.*

Fig. 4.—*A*, The bolts have been inserted through the holes (seen in Fig. 3) and the nuts are fastened onto the farther end. *B*, The method of tightening nuts is seen.

Excess length of bolt may be removed by means of cutting pliers with a high leverage factor.

The periosteum on the bone should be left as intact as possible.

The wound is closed in the routine fashion and a simple sterile dressing on the skin is used.

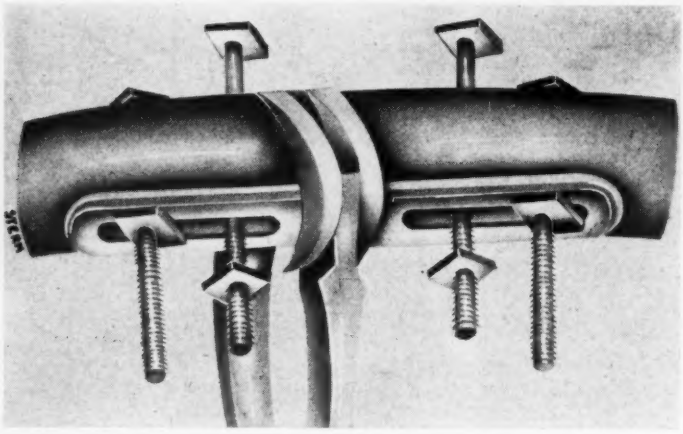


Fig. 5.—The remaining nuts are placed in position and the two end bolts are secured. At this stage of the operation the inner two bolts are left loose so that the smaller (notched) plate can be slid into position. Once this is done the inner nuts are tightened.

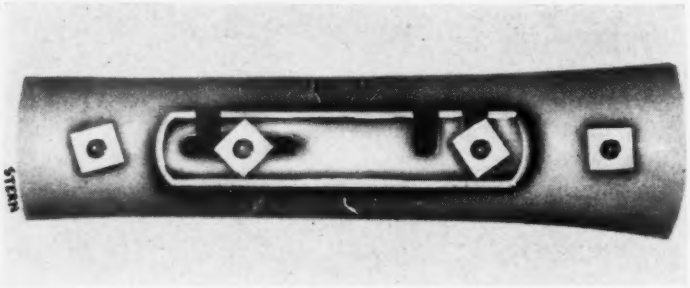


Fig. 6.—A view of the opposite side of the fracture is shown with the smaller notched plate in position and the nuts tightened.

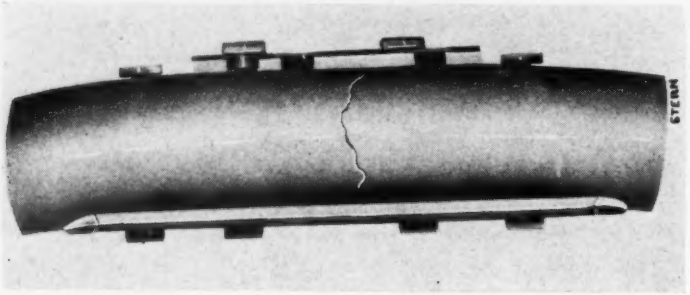


Fig. 7.—A lateral view of the fracture revealing both plates (the larger slotted and the smaller notched plate) in position and the fracture impacted.

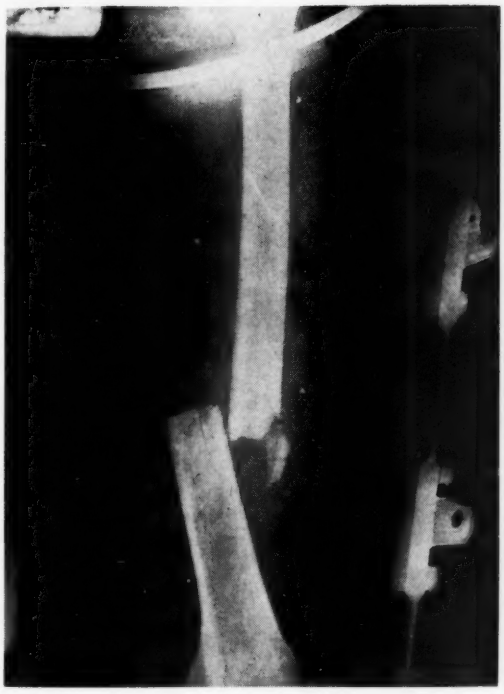


Fig. 8.

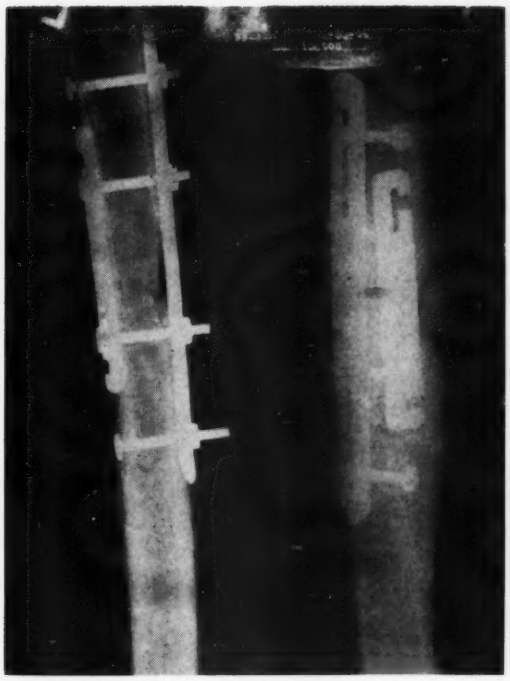


Fig. 9.

Fig. 10.

Fig. 8.—Patient was a 21-year-old boy who was in an automobile accident. Roentgenogram upon admission to the hospital revealed a transverse fracture of the shaft of the femur. A Thomas splint used in transit can be seen.

Fig. 9.—Postoperative x-ray view shows alignment of the fractured ends of the femur. The "assembly" is in situ. No plaster or other immobilizing measures have been used.

Fig. 10.—X-ray view taken two months postoperatively reveals profuse callus formation and excellent healing of the fracture.

Fig. 11.

Fig. 12.

Fig. 11.—Patient was a 59-year-old white man who sustained a fracture of the left tibia and fibula when a pile of sheet glass collapsed upon his leg.

Fig. 12.—Closed reduction of the fracture was attempted followed by immobilization with plaster. After eight weeks the bone fragments were not well approximated and there was no callus formation.

The efficacy of the assembly in immobilizing a shaft fracture without the additional use of plaster or some other splinting aid is admirably demonstrated in the following two cases.

CASE REPORTS

CASE 1.—Patient D. H. was 21 years of age. He was struck by an automobile and sustained a fracture of the shaft of the femur (Fig. 8). He was operated upon and the Wenger assembly was utilized (Fig. 9). The following day the patient was able to move about in bed flexing the knee and hip without any discomfort.

On the fifth day the patient requested bathroom privileges, which were granted. There was actual weight-bearing on that day although crutches were used and the patient continued to be ambulatory from that time on. Two months later x-ray examination (Fig. 10) showed excellent healing of the fracture.

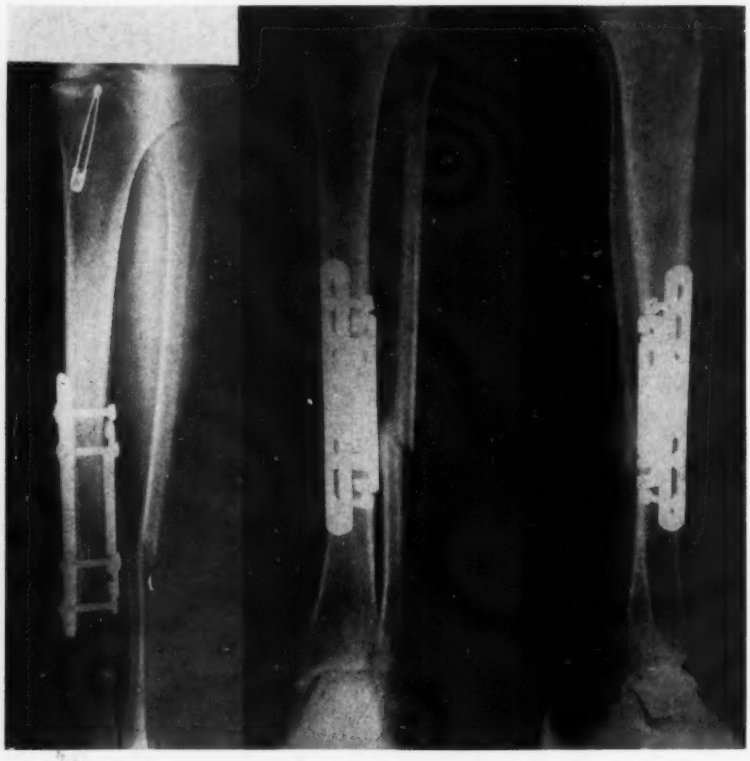


Fig. 13. Fig. 14.

Fig. 13.—An open reduction operation was performed. The Wenger apparatus was the sole form of immobilization. Good apposition of the bone fragments of the tibia was achieved.

Fig. 14.—Follow-up x-ray picture six months after operation showing healing of both the tibia and fibula with callus formation; an excellent result.

CASE 2.—Patient C. A. was a 59-year-old white man. He sustained a fractured left tibia and fibula when a pile of sheet glass collapsed upon his leg (Fig. 11). Closed reduction was attempted and the leg was immobilized in plaster. After eight weeks there was still no callus formation and the ends of the bones were not well approximated (Fig. 12).

An open reduction was therefore performed and the fractured ends of the tibia were apposed. The Wenger apparatus was the sole form of immobilization used (Fig. 13). Five days after operation the patient was able to walk and bear weight on the involved limb.

A roentgenogram taken six months later shows healing with callus formation of both the immobilized tibia and also the fibula (Fig. 14). There was excellent function of the leg.

SUMMARY

1. A new method of bone plating of shaft fractures without subsequent plaster immobilization has been described.

2. The advantages of this method are the ability to appose the fractured ends of bone and establish such a rigid fixation that no auxiliary measures of external immobilization (plaster, etc.) are required. This obviates disuse atrophy and other discomforts attendant upon nonfunction or disuse of not only the affected limb but the joints on both ends of the fracture. The patients are ambulatory in a few days and healing changes are accelerated.

3. Two cases are shown which demonstrate the efficacy and results of this method.

CONGENITAL ESOPHAGEAL ATRESIA WITH TRACHEOESOPHAGEAL FISTULA

A Case Report of Successful End-to-End Anastomosis

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LAM[6] has recently summarized the literature on surgical correction of congenital atresia of the esophagus with tracheoesophageal fistula. While this anomaly is not rare (there are over 400 cases now on record) interest in the condition has recently received a stimulus from successful reports of operations for the once uniformly fatal lesion. In 1929, Vogt[12] summarized the variations of this anomaly in the following classification which is still widely accepted: Type I, complete absence of the esophagus; extremely rare. Type II, blind end to both upper and lower segments of the esophagus, with no tracheal communication from either segment; rare. Type IIIa, upper segment with tracheal communication and a blind lower segment; rare. Type IIIb, a blind upper segment and a communication between the lower segment and the trachea; common type. Type IIIc, communication of trachea with both upper and lower segments; rare. Thus, there is only one frequent type, IIIb, comprising about 90 per cent of the cases.[7] Inasmuch as all attempts at reconstructing a functional esophagus were failures until 1941,[2] and because so few successes have been reported since that time, the presentation of this single case seems justified.

The records of the University of Virginia Hospital reveal eight cases of this anomaly, the first having been diagnosed in 1932 (Table I). Each case falls into Vogt's[12] type IIIb classification with a blind upper esophageal pouch, and the lower esophageal segment entering the trachea. The fact that five of the eight cases have been recorded in the last two years is perhaps due to a higher index of suspicion of the presence of such an anomaly in infants who present the classical syndrome. Attempts at curative surgery have been made in the five cases encountered since 1943, one patient having been operated upon elsewhere. The first two of our four attempts were made by employing the left transpleural approach. One patient (Case 4, Table I) survived a one-stage transthoracic ligation of the fistula and a cervical esophagostomy, but died eighteen days later with strangulation during a gastrostomy feeding. The regurgitation of milk proved the recanalization of the ligated fistula, which was not divided at the time of operation. This phenomenon has been reported by Ladd.[5] In the last two cases the approach was by an extrapleural posterior mediastinotomy, one on the left and the other on the right. Only one operation, the last, has been successful.

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TABLE I. CONGENITAL ATRESIA OF ESOPHAGUS WITH TRACHEOESOPHAGEAL FISTULA; SUMMARY OF CASES, UNIVERSITY OF VIRGINIA HOSPITAL

CASE NUMBER	YEAR	ASSOCIATED ANOMALIES	OPERATION	OUTCOME
1	1932	Meckel's diverticulum	Gastrostomy only	Died 44th day, of aspiration pneumonia
2	1937	Multiple; absent radius; imperforate anus; vesicovaginal fistula; supernumerary thumb; club-hand	Gastrostomy only	Died 5th day, of aspiration pneumonia
3	1940	None	Gastrostomy only	Died 26th day, of aspiration pneumonia
4	1943	None	Preliminary gastrostomy; transpleural exploration (left) one day later; ligation of fistula; esophagus not suitable for anastomosis; exteriorization of upper pouch	Died 18th day postoperative, when ligated fistula recanalized and milk was aspirated during gastrostomy feeding
5	1943	None	Primary transpleural exploration (left); diffuse attachment of lower esophageal segment to trachea, not suitable for anastomosis	Died on operating table (shock?)
6	1943	None	Primary extrapleural mediastinotomy left; segments of esophagus exposed; suitable for anastomosis	Died on operating table; death soon after pleura tore with resultant pneumothorax
7	1944	Multiple; hemivertebrae and absence of one ear	Operation elsewhere; details not known	Died soon after operation
8	1945	None	Primary extrapleural mediastinotomy on right; ligation of fistula and end-to-end anastomosis	Uneventful postoperative course; alive and well six months after operation

CASE REPORT

J. R. (case 209834), a white female infant, was born at the University of Virginia Hospital on Jan. 21, 1945, after a normal pregnancy and a slightly prolonged labor. It was noticed at birth that there was much pharyngeal mucus which required aspiration, and a marked but temporary laryngeal stridor.

Physical examination after admission to the premature nursery revealed no abnormalities except for the small weight of 2,330 grams (5 pounds, 2 ounces). At twenty-four hours the child was started on equal parts of 5 per cent glucose and normal saline solution by mouth in very small amounts, and soon thereafter a special formula of lactic acid milk with amino acids was started. It was noticed at this time that with every feeding the child would regurgitate and become somewhat cyanotic. Because the child continued to vomit, everything by mouth was withheld on the third hospital day and an intravenous drip of 300 c.c. of Ringer's lactate solution was given. On the completion of this drip the formula was again started with repetition of choking and cyanosis.

Because of repeated regurgitation of everything taken by mouth, a small catheter was passed into the esophagus on the morning of the fourth hospital day (third day of life), and an obstruction was met about halfway down the length of the esophagus. The patient was taken to the x-ray department and 2 c.c. of iodized oil were injected into the esophagus by catheter. A complete atresia of the esophagus with a large bulbous upper segment extending as far down as the second dorsal vertebra was noted on fluoroscopy. Roentgeno-

grams confirmed the fluoroscopic findings and also showed a large amount of gas in the stomach and intestinal tract (Fig. 1). There was no evidence of pneumonia.

A diagnosis of atresia of the upper portion of the esophagus with tracheoesophageal fistula of Vogt's type IIIb was made and the patient was prepared for immediate operation with an intravenous drip of 50 c.c. of ⅙ molar sodium lactate and 250 c.c. of Ringer's lactate solution.

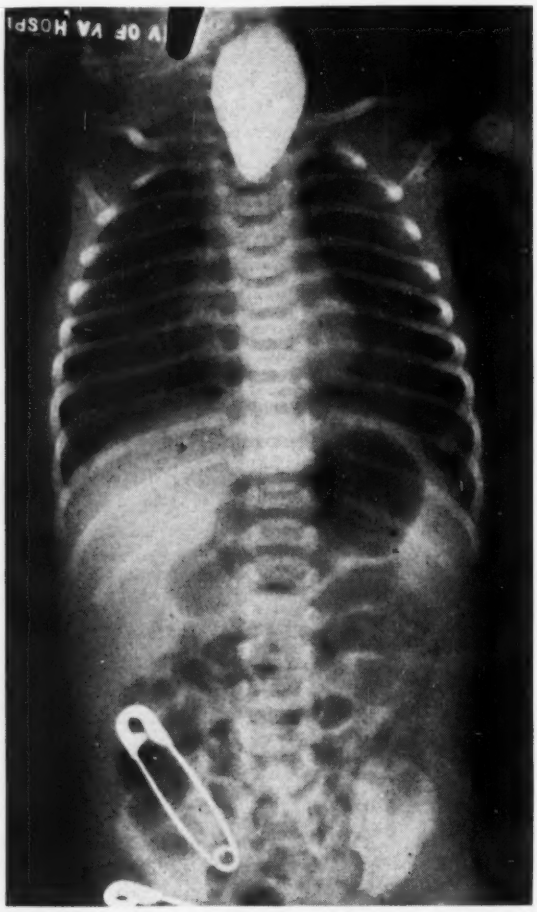

Fig. 1.—Preoperative roentgenogram after the injection of iodized oil into the esophagus, showing blind upper esophageal pouch, normal lung fields, and the gas-filled gastrointestinal tract.

Operation.—On Jan. 24, 1945, the following operation was performed by one of us (M.L.W.). Under local infiltration anesthesia (½ per cent novocain) a 5 cm. incision was made on the right side between the scapula and the spinous processes beginning at the second rib and extending to the sixth. The extracostal muscles were divided and the sacrospinalis was retracted. Vessels were ligated with fine black silk. The third, fourth, and fifth ribs were resected subperiosteally from the transverse processes anteriorly to a point about 1 cm. beyond the angles of the ribs. The intercostal bundles were ligated with fine silk and divided. By blunt dissection the parietal pleura was separated from the endothoracic fascia posteriorly until the mediastinum was entered. The azygos vein was identified, doubly ligated with fine silk, and divided. The large upper blind pouch of the esophagus was easily identified and dissected free as was the lower segment also, since it extended almost to the upper segment. Although much smaller in diameter it appeared to have a lumen adequate for

anastomosis. The lower segment was attached to the trachea about ½ cm. inferior to the upper segment. A tracheoesophageal fistula at this point was isolated; after transfixing ligatures were placed in the wall of the fistula close to the trachea, the fistula was divided, opening the lumen of the distal segment of the esophagus. The lumen of the upper segment was entered by amputating the bulbous tip of the upper segment.

At this point in the operation the lighted retractor which was holding the lung forward accidentally injured the parietal pleura and a sucking pneumothorax resulted. An attempt was made to give oxygen under positive pressure, which was only partially successful. Because of the violent respiratory movements, a small quantity of ether was administered by the

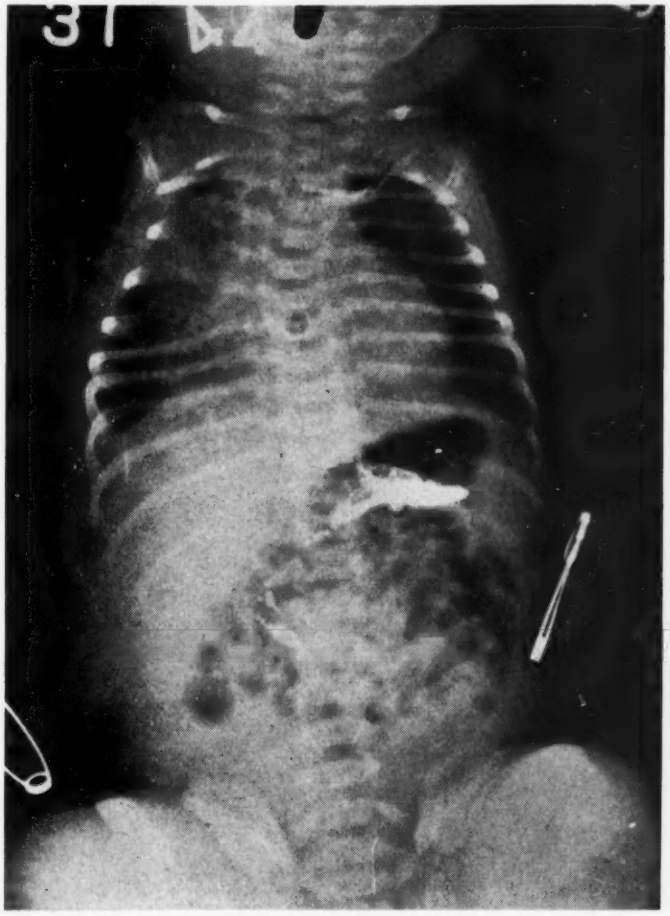

Fig. 2.—Roentgenogram on sixth postoperative day after the ingestion of iodized oil. The oil passed into the stomach very rapidly and did not outline the esophagus. A moderate pneumonitis persists in the right upper lobe adjacent to the field of operation.

open drop method, but this was soon discontinued because of cyanosis. Since the hole in the parietal pleura was so large that it could not be repaired, a sponge was placed over the defect and the retractor reapplied. After about five minutes the respiration became quiet and regular and the child's condition permitted resumption of the operation.

A No. 8 French urethral catheter was passed into the stomach through the distal segment of the esophagus, and its upper end was passed through the upper segment into the pharynx where it was retrieved by the anesthetist. The two ends of the esophagus could then be brought together over the catheter and held by traction sutures. With interrupted

very fine silk sutures the first layer of the anastomosis was placed, approximating the thick mucosa of the upper segment to the full thickness of the thin-walled lower segment. A second row of similar sutures approximated the muscularis of the upper segment to the muscularis of the lower segment about 3 mm. distal to the first line of sutures. This row tended to telescope the lower segment into the upper segment. After an apparently satisfactory closure the catheter was removed through the mouth.

Sulfanilamide crystals were scattered through the wound, which was closed in layers with interrupted silk sutures, leaving a small catheter in the pleural space through the accidental pleural defect. After the skin had been closed, a small amount of air was aspirated from the pleural space, and 20,000 units of penicillin were injected. The catheter was then removed, leaving no drain there or in the mediastinum.

During the operation, 5 per cent glucose and a transfusion of 50 c.c. of whole blood were administered through a scalp vein. The infant's condition at the conclusion of the operation was fairly good in spite of the long tedious procedure and the fact that the pleural space was inadvertently widely opened. There was mild cyanosis on return to the nursery.

Fig. 3.—Patient two and one-half months after operation; weight 11 pounds, ¼ ounce.

Postoperative Course.—The patient was kept in an oxygen tent in a head-down position for four days and given 3,000 units of penicillin intramuscularly every three hours for three weeks.

At first nothing was allowed by mouth, and the child was maintained intravenously with sodium lactate, 5 per cent glucose, 5 per cent amino acid* solution and citrated whole blood until the fourth postoperative day. At this time 2 c.c. of equal parts of 5 per cent glucose and normal saline solution were given by mouth and repeated at two hourly intervals. On the sixth postoperative day the same amount of 5 per cent amino acid solution

*Mead Johnson's Amigen was the source of the amino acids. It consists of 5 per cent amino acids in a 5 per cent glucose solution with 0.2 per cent sodium chloride.

was substituted for the normal saline solution. The patient took these first feedings so well that on the ninth postoperative day she could be started on a special lactic acid formula* with the addition of amino acids. Thereafter, the patient's intake was gradually increased and she took the feedings without difficulty. During this time the child was given blood transfusions of 50 to 60 c.c. every other day. A part of the needed fluid was given in the form of 5 per cent amino acid solution intravenously.

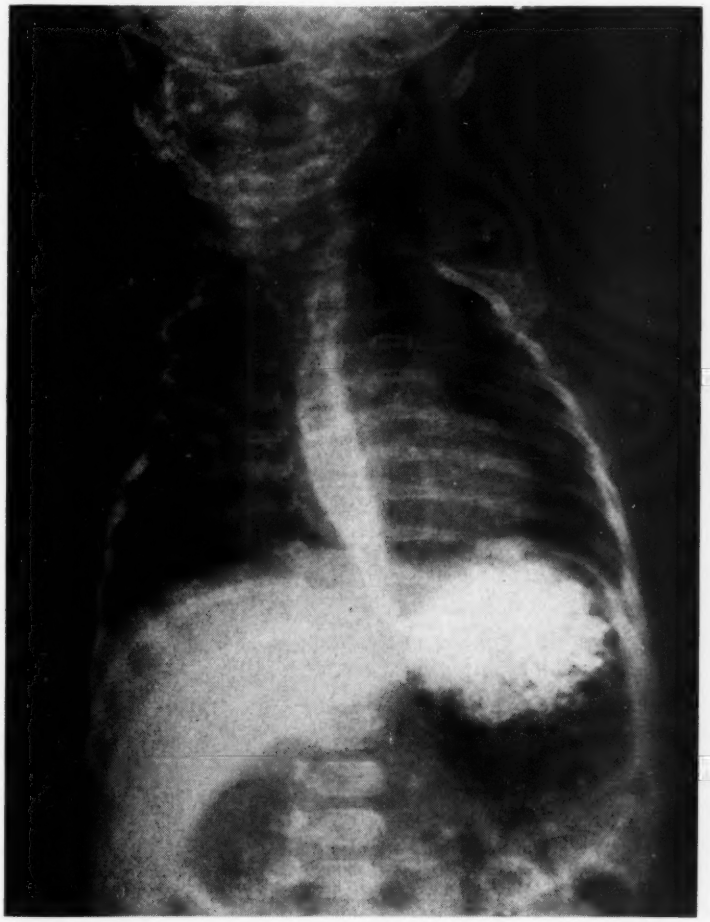

Fig. 4.—Roentgenogram two and one-half months after operation. Barium was used as the contrast medium. The esophagus appears normal. The lungs are clear and the resected ribs have regenerated.

On the day following operation, moderate edema was noted which for about six days gradually increased with corresponding gain in weight. On the twelfth postoperative day the patient began to lose weight and did so for six days, at which time all the edema had disappeared. At this time weight began to increase steadily at a normal rate and continued to do so until her discharge from the hospital.

The extrapleural wound space was aspirated with a hypodermic needle daily for the first five postoperative days, yielding an average of 10 to 15 c.c. of serosanguineous fluid, cultures of which were consistently negative. On the fifth day only 2 c.c. were obtained. Penicillin (10,000 units) was injected into the wound space after each aspiration.

*The special lactic acid milk formula consists of 16 ounces of whole cow's milk with only 2 per cent fat, 1 ounce of Cartose, 1 dram of lactic acid, and 1 ounce of Amigen. This gives a formula of 25 calories per ounce.

On the third postoperative day the patient was fluoroscoped after the injection of 2 c.c. of iodized oil into the esophagus. After a brief delay at the site of the anastomosis, the iodized oil readily passed into the stomach (Fig. 2). Repeated x-ray examinations with iodized oil were made during the next two weeks, and at no time was any leakage around the anastomosis or any significant stricture seen. Except for a minor upper respiratory infection and a mild diarrhea for two days in the latter part of the hospitalization, the patient's course after the first two weeks of life was uneventful.

The patient was discharged on the forty-fourth hospital day, thirty-nine days after operation, in excellent condition and weighing 2,930 grams, a gain of 600 grams over the birth weight. She has been followed in the outpatient department at intervals of two weeks for nine months, and has a normal curve of weight gain. At no time has there been any difficulty in swallowing or any regurgitation. On April 4, 1945, approximately two and one-half months after operation, the child appeared well nourished (Fig. 3) and barium studies of the esophagus revealed a normal appearance with no evidence of stricture (Fig. 4). On May 16, 1945, the patient weighed 11 pounds and ¼ ounce. On Oct 15, 1945, nine months after operation, the child was in excellent health, weighed 16 pounds and 4½ ounces, and showed entirely normal development.

COMMENT

The diagnosis in the case reported was suspected when the child began to vomit her food immediately after ingestion, and in the intervals to eject continually a small amount of foamy saliva. Cyanosis, especially at feeding time, was also a noteworthy symptom. These are classical signs of the type IIIb tracheoesophageal fistula. A small rubber catheter passed into the esophagus revealed an obstruction. A diagnosis of atresia of the esophagus was then fairly obvious and needed only confirmation by x-ray.

Contributions to the development of the surgery of this anomaly by Haight and Towsley[2, 3] deserve the utmost credit. Haight not only performed the first successful anastomosis (1941), but also has operated in six of the thirteen successful cases now recorded in the literature.[1-6, 11] The indirect method of surgical attack (ligation of the fistula, gastrostomy, and cervical esophagostomy, planning the eventual formation of an antethoracic esophagus) was first successfully performed in 1940 by Leven[8] and one day later by Ladd.[5] Nineteen patients have survived this method of attack although the antethoracic esophagus has not been completed in all.[4-6, 8, 9] It is important to note that 70.8 per cent of the twenty-four patients operated upon by Haight[3] had a morphology suitable for end-to-end anastomosis, and that all six of the surviving patients had this type of operation. Nine of eleven surviving patients reported by Ladd[5] have had the long and complicated indirect method of attack.

There would seem to be no difficulty in choosing between the one-stage direct anastomosis and the indirect method from the point of view of functional end results. With the former, the patient has, following a single procedure, an esophagus approximating the normal; with the latter, he has, after a prolonged convalescence marked by multiple plastic operations, only a substitute for an esophagus. The data are as yet too incomplete to permit any positive conclusions on the relative operative risk of the two primary procedures. In our judgment there is only one reason for the indirect approach, namely, an anatomic condition

that will not permit direct anastomosis, which, unfortunately, is frequently encountered. The parents of one of our patients requested that no procedure be carried out if a direct anastomosis should prove impossible.

The operative technique of Haight[3] was followed closely in the case reported and needs no further comment. After having tried both the transpleural and the extrapleural approaches (Table I) we greatly prefer the latter and we find the attack easier on the right than on the left side. The telescopic method of anastomosis over a small catheter is easily performed in a suitable case.

One significant variation from previously published methods is the failure to place a drain at the site of anastomosis. It was felt that penicillin used locally in the extrapleural space might maintain asepsis in the region of the anastomosis and minimize, thereby, the danger of infection and breakdown of the anastomotic suture line. The closed extrapleural space was aspirated daily for five days and penicillin injected after each aspiration. In the absence of a drain a higher concentration of penicillin can be maintained in the threatened space than in the presence of a drain.* Lam[6] has recently used penicillin both systemically and locally but drainage was carried out in his cases.

This case is believed to be the fourth recorded case which did not include a supplementary gastrostomy. Gastrostomy was required in three of Haight's[3] six cases, and the procedure has been used in all of the other successful cases reported by various authors either as a preliminary operative procedure or because of leakage of the anastomosis, or stricture. When gastrostomy can be avoided, the postoperative course is transformed from a difficult feeding and nursing problem of indefinite duration into one of parenteral maintenance for a few days, followed permanently by normal oral feedings. Penicillin, by lessening the incidence of anastomotic leaks, will probably decrease the need for gastrostomy.

The three important points in the postoperative care are the prevention of infection, the control of body temperature, and the maintenance of nutrition. The two former points need no particular comment, being comprised of routine procedures for the premature nursery with the addition of intramuscular penicillin. However, nutrition will probably always present an individual and difficult problem.

Probably the most difficult part of the nutrition problem in these infants is the maintenance of fluid balance, which is, of course, intimately concerned with electrolyte balance. Haight[3] has noted the frequent occurrence of generalized postoperative edema, which, localized in the anastomotic suture line, might well result in failure to heal and consequent leakage. Schemm[10] has shown that patients may be given large quantities of fluid with impunity if the intake of sodium ion is low. Although the generally accepted fluid requirement of newborn infants is taken to be from 2½ to 3 ounces per pound (165 to 200 c.c. per kilogram) per day with wide variations between individual patients, the patient

*This principle has been utilized in this hospital in the treatment of the pleural space following resection of the lung in a series of cases, the report of which is in press.

reported upon here received only about 1½ ounces per pound per day during the period of intravenous maintenance. In spite of this low fluid intake, edema promptly developed postoperatively. The most logical explanation would seem to be the sodium taken in the form of sodium lactate, Ringer's solution, and normal saline solution both before and after operation. Certainly the other common causes of edema, such as low serum protein, circulatory failure, and capillary damage from anoxia, did not seem to be factors in this case. The balance in the newborn infant between edema on the one hand and dehydration on the other is delicate enough without the added handicap of abnormal gastrointestinal function. The weight and the other clinical manifestations of fluid balance must be closely watched in these cases. Fluid can be given as normal sodium chloride, 5 per cent glucose, or 5 per cent amino acid according to nutritional needs. In our next case we plan to limit the sodium intake still further.

The necessity to prevent ketosis in these infants is obvious. All fluid which is not given to meet the electrolyte and protein needs is given in the form of 5 per cent glucose. If this amount of sugar is not sufficient to prevent ketosis, it can be given in mixed solutions of glucose with sodium chloride or with amino acids.

The administration of protein is essential both to prevent edema and tissue waste, and to promote wound healing. It must be remembered that these patients have been starved from birth until operation, a period of from one to many days. Since protein foods cannot be allowed by mouth for from six to ten days postoperatively, they may be without oral protein nitrogen intake for from ten to fourteen days or longer. The resulting nitrogen deficiency can be made up by the intravenous administration of amino acids supplemented by blood transfusions, and by early administration (sixth day) of amino acids by mouth. Ascorbic acid must also be given in doses of 100 mg. daily to aid in wound healing.

We believe that postoperative maintenance by the intravenous route was a factor in the successful result in this case. A constant drip was used, employing the scalp veins. The rate of administration can be better controlled with a very slow drip for long periods of time. With this method there is also less chance of abscess formation or sterile necrosis, and because one drip a day is all that is necessary, the infant is not disturbed as frequently. There were no reactions following the intravenous use of amino acids.

In conclusion, we feel that there should be the closest cooperation between the thoracic surgeon and the pediatrician in the handling of these cases. Certainly intelligent attention to the metabolism postoperatively is as important in the recovery of these infants as is the technique of the operation.

SUMMARY

A case of congenital esophageal atresia with tracheoesophageal fistula has been presented. The details of the diagnosis, operation, and postoperative care have been discussed.

REFERENCES

1. Daniel, R. A., Jr.: Congenital Atresia of the Esophagus: With Tracheo-esophageal Fistula, Ann. Surg. **120**: 764, 1944.
2. Haight, C., and Towsley, H. A.: Congenital Atresia of the Esophagus With Tracheo-esophageal Fistula: Extrapleural Ligation of Fistula and End-to-End Anastomosis of Esophageal Segments, Surg., Gynec. & Obst. **76**: 672, 1943.
3. Haight, C.: Congenital Atresia of the Esophagus With Tracheoesophageal Fistula: Reconstruction of Esophageal Continuity by Primary Anastomosis, Ann. Surg. **120**: 623, 1944.
4. Humphreys, G. H.: The Surgical Treatment of Congenital Atresia of the Esophagus, SURGERY **15**: 801, 1944.
5. Ladd, W. E.: The Surgical Treatment of Esophageal Atresia and Tracheoesophageal Fistulas, New England J. Med. **230**: 625, 1944.
6. Lam, C. R.: The Surgical Treatment of Congenital Atresia of the Esophagus With Tracheo-esophageal Fistula, Quart. Bull. Indiana Univ. M. Center **7**: 32, 1945.
7. Lanman, T. H.: Congenital Atresia of the Esophagus: A Study of Thirty-Two Cases, Arch. Surg. **41**: 1060, 1940.
8. Leven, N. L.: Congenital Atresia of the Esophagus With Tracheo-esophageal Fistula: Report of Successful Extrapleural Ligation of Fistulous Communication and Cervical Esophagostomy, J. Thoracic Surg. **10**: 648, 1941.
9. Nettrour, W. S.: Case Report of Broncho-esophageal Fistula, Pittsburg Medical Bulletin **31**: 128, 1942.
10. Schemm, F. R.: High Fluid Intake in Management of Edema, Especially Cardiac Edema; Details and Basis of Regime, Ann. Int. Med. **17**: 952, 1942.
11. Shaw, R.: Personal communication quoted by Haight.[3]
12. Vogt, E. C.: Congenital Esophageal Atresia, Am. J. Roentgenol. **22**: 463, 1929.

TREATMENT OF ESOPHAGEAL ACHALASIA OR CARDIOSPASM

Report of Four Patients Treated Surgically

H. Max Schiebel, M.D., Durham, N. C.

DYSPHAGIA, retrosternal pain, and regurgitation of food are distressing and fearful symptoms for any patient to experience. The determination of the actual cause of such symptoms requires thorough investigation, and the humane aspect of therapeutic principles demands attention directed toward relief.

This symptom complex has been recognized for a long time and observations have been recorded as long ago as 1679.[1] In that year a volume on *Pharmaceutice Rationalis* was published by Thomas Willis in which the following description is contained.

> Of Vomiting.
>
> No less will a very rare case of a certain Man of Oxford shew, an almost perpetual Vomiting to be stirred up by the shutting up of the left Orifice. A strong Man, and otherwise healthful enough, labouring for a long time with often Vomiting, he was wont, very often, though not always, presently to cast up whatsoever he had eaten. At length the Disease having overcome all remedies, he was brought into that condition, that growing hungry he would eat until the Oesophagus was filled up to the Throat, in the mean time nothing sliding down into the Ventricle, he cast up raw (or crude) whatsoever he had taken: when that no Medicines could help and he languished away for hunger, and every Day was in danger of Death, I prepared an instrument for him like a Rod, of a whale Bone, with a little round Button of Sponge fixed to the top of it; the sick Man having taken down meat and drink into his Throat, presently putting this down in the Oesophagus, he did thrust down into the Ventricle, its Orifice being opened, the Food which otherwise would have come back again; and by this means he hath daily taken his sustenance for fifteen Years and doth yet use the same Machine, and is yet alive, and well, who would otherwise perish for want of Food. Without doubt in this case the Mouth of the Stomach being always closed, either by a Tumour or Palsie, nothing could be admitted into the Ventricle unless it were violently opened.

In this very clear description we see not only a fairly complete account, but also an ingenious method of treatment which, with a few modifications, is still in common use. Again, in 1889, there appeared in the *Boston Medical and Surgical Journal* a description by Osgood[2] of six patients suffering from dysphagia.

> The distress was always located beneath the xiphoid cartilage as high as its union with the gladiolus, and here tenderness on pressure is usual. From its point of origin the discomfort, which is very peculiar in character, may radiate up to the pharynx and from that locality pass into one or both ears. . . . When the entire tract of the esophagus is thus involved the distress is very annoying and is apt to alarm the patient. . . . There is the sense of impending suffocation. . . . Sometimes the distress appears to the right of the median line and gradually involves the right chest as far as the outer border of the mamma, being sharply felt in the nipple. In extreme cases pain is felt in the back. . . . At all times there existed difficulty in

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> swallowing beer, champagne, apollinaris water, and other gaseous drinks. As soon as the fluid reached the lower end of the esophagus a spasmodic, but only momentary, constriction followed. . . . It is during the existence of an obstinate attack that the sufferer complains of a strange sensation of pain in one ear, very rarely both ears, and not at all in some cases. . . .

Incidence.—Achalasia is seen rather frequently and is second only to carcinoma as a cause of difficulty in swallowing. Guisez[3] found that 17.4 per cent of 946 patients requiring esophagoscopic examinations for dysphagia or pain had achalasia. In Walton's[4] series 17.8 per cent of all esophageal lesions were due to achalasia.

In 1904 Von Mikulicz[5] collected 100 cases from the literature, and, by 1940, 1,200 cases had been reported by one group of workers.[6]

Symptoms.—The symptoms consist primarily of pain, dysphagia, and regurgitation of food. Pain is present in 60 to 70 per cent of the cases in sharp contrast to the absence of pain in carcinoma. Also, in many instances solid foods can be taken as well as and sometimes even better than liquids. Cold drinks and cold foods are most poorly tolerated. One of my patients had been unable to eat ice cream for eleven years. Pain is not confined to periods of eating, but may appear at any time, even during the night. It is substernal, and may radiate into the cervical region, the angle of the jaw, and the mastoid region (Alvarez).[7] In some instances it is also felt in the back at the level of the tenth to the twelfth thoracic vertebrae. Loss of weight is common. The vomitus sometimes comes immediately after eating or may not occur until night and only after several days. In milder instances the patient may get along without vomiting but will have to eat standing up, eating slowly and drinking warm fluids along with the meal. Periods of exacerbation may develop during which nothing can be taken for several days. These frequently correspond with emotional conflicts (Comby,[8] Jacobson,[9] Muggia,[10] Bruhl,[11] Sudhues,[12] and Weiss[13]), but in some instances no such psychosomatic relation can be discovered. In certain cases what appears to be primary achalasia is aggravated by the fear of regurgitation so that the patient does reasonably well at home but is unable to eat in any public place or away from home. I have seen cases in which spasm was secondary to gall bladder disease, esophagitis, foreign body in the esophagus, peptic ulcer, and diaphragmatic hernia, and all these must be ruled out. Carcinoma must be differentiated. Clinically, carcinoma produces less discomfort and more gradual interference with swallowing, steadily progressive from solid foods to liquids.

Roentgenographic studies usually show a smooth, olive-tip type of obstruction at the cardia, with or without dilatation of the esophagus above. This may not be well outlined at first because of accumulated food in the esophagus. Esophagoscopic examinations may show considerable esophagitis secondary to retention of food.

Etiology.—The etiologic factors responsible for the failure of the passage of solids and liquids through the junction of the esophagus and the stomach are probably many and varied, as evidenced by the numerous diagnostic names applied. These include cardiospasm, congenital dilatation of the esophagus,

phrenospasm, achalasia of the cardia, atony of the esophagus and megaesophagus, kinking of the esophagus, pressure from the left lobe of the liver, fibrosis of the periesophageal connective tissue, esophagectasia, and the ever-present idiopathic dilatation of the esophagus. The most recent addition has been "cardiospasm, a psychosomatic disorder."[13]

As in other branches of medicine, it is quite likely that this long list means either that the disease has many contributing factors or that the true agent has not yet been discovered. Rather complete discussions of causative agents are included in the articles of Ochsner and DeBakey,[14] Schmidt,[15] Heyrovsky,[16] Vinson,[17] and others. A very brief discussion will suffice to indicate these theoretical backgrounds and their resultant trends in therapy.

The congenital theory has had two groups of followers, those concerned with the main body of the esophagus, and those thinking in terms of the cardia. In 1897 Jaffie,[18] thinking along the former line, suggested removing longitudinal ribbonlike strips from the wall of the dilated portion. This procedure was attempted, as well as simple pleating or plication of the wall longitudinally, without actual incision. Both attempts gave very poor results and were abandoned by 1911. Freeman,[19] thinking in terms of congenital elongation rather than dilatation, advocated and carried out an artificial intussusception of the cervical portion into the midthoracic portion through a cervical incision.

More rational and also more numerous have been the procedures based on the theory of congenital spasm or stricture of the cardia. In 1899, Mikulicz dilated the cardia by opening the stomach and inserting a finger up through the cardioesophageal junction. Later he devised an instrument for performing the dilatation through the invaginated anterior wall of the stomach, thus avoiding the contamination of the peritoneal cavity entailed in opening the stomach. It is interesting to note, however, that Heller[20] later reoperated upon two of these patients for the same condition. Obviously the cure was by no means permanent.

Although an operation similar to the Fredet-Rammstedt procedure had been suggested quite early, it was first performed by Heller in 1913. This was used by Heller twenty-one times by 1921, with the results reported as 80 per cent improved and 20 per cent poor. There was no mortality in his series, but in the hands of others the mortality has risen to 3.8 per cent in 104 cases collected by Ochsner and DeBakey with indifferent results or actual recurrences in about 19 per cent.

In 1910 Heyrovsky first performed an esophagogastrostomy, leaving the actual cardioesophageal junction undisturbed. This acted much as a spur and results were greatly improved when Womack[21] modified this in a fashion not unlike the Finney pyloroplasty.[22] Haggström[23] reported twenty-nine patients successfully treated in this manner and others have been reported by Ochsner and DeBakey,[14] Kredel,[24] Sprunt and Harrill,[25] and Wachs.[26] I have used this procedure, termed cardioesophagoplasty, in the four cases cited in this report. There are at present at least 115 patients treated in this manner, with five deaths, one poor result, and one only moderately improved. It is interesting that the one poor result and the mortality of five all occurred prior to 1938. The use of

sulfonamides and penicillin should continue to keep the present mortality figures low. Kredel's[24] one patient had to have four dilatations about two months after the operation but was reported entirely well fourteen and one-half months later.

Some mention must be made of the various procedures based upon neurogenic theories. It is known anatomically that sympathetic fibers proceed to the esophagus from the inferior cervical ganglion and the celiac plexus.[8] Fibers from both vagi also enter it and it is because of these that a bolus of food in the esophagus initiates peristaltic action. Section of these fibers alone does not produce cardiospasm. In the follow-up examinations of the patients with peptic ulcer treated by transthoracic bilateral vagotomy about 6 to 8 cm. above the diaphragm, no cases of cardiospasm or achalasia developed, although atony of the stomach did develop in all instances, in fact to an alarming degree in some.[27]

Experiments of Grondahl and Haney[28] showed that in dogs achalasia would develop if the vagi were both cut 4 cm. above the diaphragm and the esophageal muscle was divided down to the submucosa, but not if either one alone was performed. Knight,[29, 30] working with cats (the musculature of the esophagus in cats, apes, and man is composed of the same fiber types), in 1934, felt that he could not only produce achalasia by bilateral vagal section but that he could relieve it by sympathectomy. Knight and Adamson[30] reported sympathectomy in five patients with, however, only one resulting in complete relief and with three recurrences. In one case reported by Schmidt,[15] bilateral cervicodorsal sympathetic ganglionectomy and trunk resection was performed with complete relief for fifty-two hours, after which sudden and complete closure of the esophagus appeared so that gastrostomy had to be performed. Esophageal dilatations were used for eighteen months before the ability to swallow returned.

The various types of medical therapy have been based upon attempts to stimulate or inhibit the activity of the sympathetic and parasympathetic systems. Experimentally in human beings, with soft rubber balloons fixed in the cardia, morphine sulfate and amyl nitrite caused temporary relaxation. Benzedrine sulfate produced relaxation for one hour followed by severe spasm for two hours. Insulin in doses sufficient to produce symptoms of hypoglycemia brought about relaxation during the hypoglycemic period. Adrenalin, sodium nitrate, mecholin and metrazol showed no definite relaxation. Subcutaneous and intravenous atropine sulfate produced no consistent results. Vinson[17] stated that some of his patients have been improved with atropine, and others have received as much as 1.8 mg. ($\frac{1}{25}$ gr.) intravenously every hour until symptoms of poisoning developed with no evidence of relaxation of the cardia. Douthwaite[32] used amyl nitrite in the treatment of achalasia and found that although the period of relaxation was very short, frequent inhalations over a period of several months seemed to diminish the strength of the obstructive force.

In the vast majority of cases, dilatation or mechanical stretching of the esophagus has proved successful. We have seen how this was the procedure of Mikulicz. Probably it was also the principle in the case reported by Willis, although he interpreted it as a tamping process. This simpler method of in-

troducing a sound through the mouth has been used in more than 1,200 cases reported from the Mayo Clinic, and probably in 1,000 other unreported cases by various men throughout the country. A breakdown of cases in 805 patients treated in this manner showed 670, or 71 per cent, well, with one or more dilatations. In thirty-two there was no improvement. One hundred three considered themselves better but not well. Nine died in the hospital due to splitting of the esophagus, and two died of starvation. Twelve others died at home during the treatment, with the actual cause unknown.[33] The use of the Russell hydrostatic dilator is advocated by Plummer (quoted by Vinson[17]), Hoover,[34] and many others as a relatively safe procedure, since in most instances pain is produced by dilatation of the cardia.[7] This enables the operator to judge the amount of pressure which may be used.

Pathology.—The gross pathology is much more significant than the microscopic. Lambert[35] divided the gross findings into three types, fusiform, S-shaped or sigmoid, and flask (see Fig. 1). These types probably represent variations in the degree of dilatation and lengthening of the esophagus subsequent to its obstruction. In determining optimal therapy, this degree of change must be considered. Rake[36] reported finding degeneration of nerve fibers in Auerbach's plexus. In some cases the wall becomes thicker but in others it appears normal. Hypertrophy and ulceration of the mucous membrane may occur.

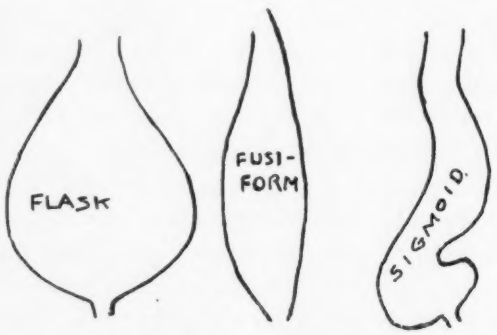


Fig. 1.—Three usual gross pathologic types of esophageal dilatation.

The major complication without therapy has been pulmonary infection due to regurgitation of food. This sometimes occurs at night, without the patient's knowledge, simply as an overflow from a filled esophagus. Other complications are aggravation of already existing emotional instability, bleeding, and chronic cough. Death due to starvation has occurred. The complications following or during treatment by dilatation are the same as those previously mentioned, with the addition of rupturing the esophagus. Those following open operation are primarily infection with resultant peritonitis or mediastinitis and empyema, depending upon the use of the transabdominal or transthoracic approach.

Essential Indications for Therapy and Guides as to Choice of Therapy.—One undoubtedly sees, in practice, many degrees of achalasia or cardiospasm. In fact, it can frequently be produced in an individual having no actual difficulties

by the giving of ice cold water when greatly overheated and exhausted by physical activity. Some have mild symptoms only in the morning or only when emotionally disturbed. Opposing these mild cases, one sees patients who (a) lose weight or, having lost weight, remain in a more or less constant undernourished state, (b) those in whom dysphagia is marked and associated with substernal pain and feelings of suffocation, and (c) those with actual vomiting. In these three types of cases it becomes necessary to institute some type of treatment more than simple advice concerning slow and thorough mastication, rest

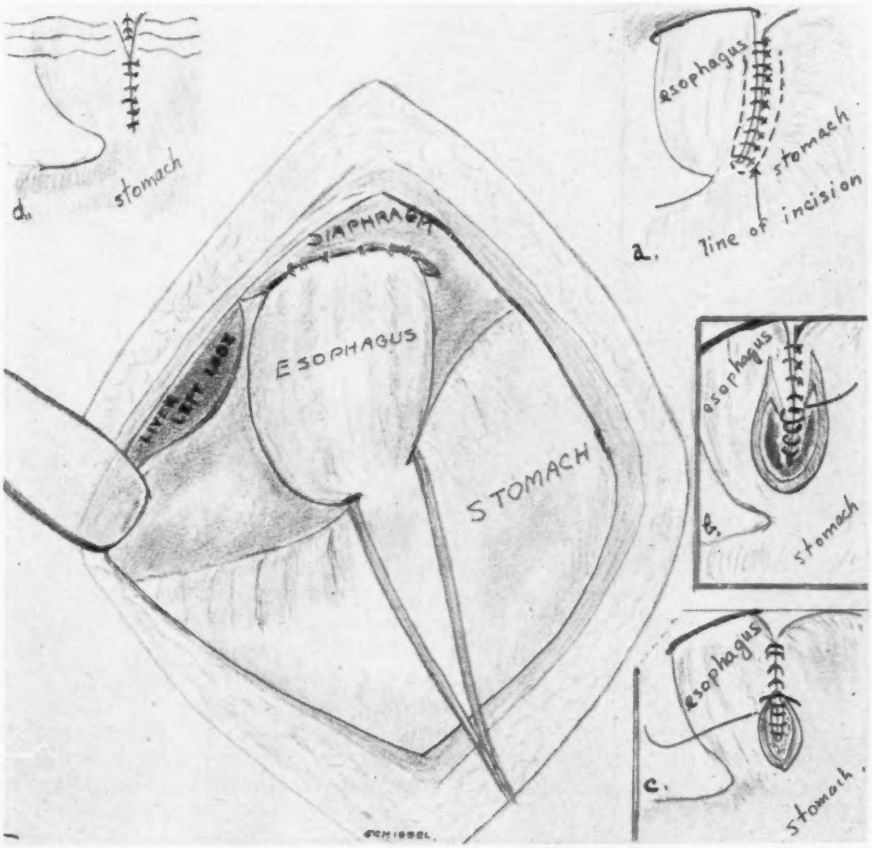


Fig. 2.—Esophagogastrostomy. Approach through a left rectus incision. The left lobe of the liver is retracted to the right after cutting the triangular ligament. The dilated esophagus has been pulled down through the opening in the diaphragm and is held by a linen tape or a soft rubber tube. In *a*, *b*, *c*, and *d* are shown the usual steps in performing a two-layer esophagogastrostomy.

before and after meals, use of warmed foods only, and antispasmodics. Dilatation by the passage of bougies and the use of the hydrostatic dilator becomes necessary, at first either with the aid of esophagoscopic examination or under fluoroscopic observation and later without such aid. In many instances, as the literature records, this is very effective. When, then, shall we institute a surgical approach such as cardioesophagoplasty? In my opinion, the following indications exist.

1. When roentgenographic examination discloses increased length of the esophagus with a sigmoid- or flask-shaped contour. In these dilatation is difficult, dangerous, and usually must be kept up more or less continuously.

2. When the patient, under proper care as to rest, types of food, and reasonably free from simple emotional exacerbation, necessitates dilatation frequently, such as once a week or several times each month. Under such circumstances the patient should be advised that an operative procedure is available which carries a high percentage of cures.

3. When the patient does not tolerate the procedure well because of fear and pain and has no possibility of learning the use of bougies without medical aid.

4. Finally, when the patient is geographically or financially unable to have frequent dilatations.

When such factors exist, operation is indicated and desirable. The technique has been adequately described by Ochsner and others (see Fig. 2). The transperitoneal approach is preferred and the operation is not a difficult one. Both spinal and inhalation anesthesia have been used with identical results. The following case histories illustrate common symptoms, findings, and results to be expected.

CASE REPORTS

CASE 1.—J. R., a 56-year-old colored man, tenant farmer, was admitted to Lincoln Hospital on Jan. 19, 1943, complaining of inability to swallow food or water for three days. His general health had always been good until five or six years before admission. Since then he had had occasional attacks of nausea coming on immediately after eating and lasting one or two days. Ten months before, and continuing until admission, he began to have frequent bouts of vomiting after eating, with regurgitation of food, both solid and liquid. Attacks of this were very severe for two to three days, and then much improvement took place for a few days. For three days prior to admission he had not even been able to swallow water. He lost eighty pounds in the preceding nine months. Previous roentgenograms had been made but were not available. Several dilatations had been attempted unsuccessfully.

On examination, nothing unusual could be found except obvious dehydration and weight loss. The skin was loose and inelastic. Height was 76 inches, weight 170 pounds. Roentgenograms showed elongation and dilatation of the lower portion of the esophagus and complete obstruction with a smoothly rounded lower end (see Fig. 3). A diagnosis of cardiospasm was made and operation advised. Adequate fluids and vitamins were administered and the esophagus lavaged twice daily.

On January 25, operation was performed under spinal anesthesia, 20 mg. of pontocaine. Prior to beginning this, the phrenic nerve was visualized on the left side of the neck under local anesthesia and was crushed. An upper left rectus incision was made. The abdominal contents appeared normal. The suspensory ligament of the left lobe of the liver was divided and the lobe retracted toward the right side. The cardioesophageal junction was visualized. The peritoneum covering this was incised. The vagus nerves were identified and avoided. The esophageal hiatus was dilated and the esophagus gently mobilized until 12 cm. was brought below the diaphragm. It was dilated to about 5 to 6 cm., and the wall was quite thickened. The musculature at the cardioesophageal junction appeared normal, but the opening seemed very small. The esophagus was sutured to the diaphragm at the new level. A posterior row of interrupted No. 40 cotton sutures was placed joining the stomach and the esophagus. A U-shaped incision was then made through all the layers of the esophagus and the stomach, each limb being about 4 to 5 cm. long. A continuous No. 00 chromic catgut suture united these raw edges. A final anterior row of cotton sutures was placed. After this the redundant

portion of the stomach was loosely attached to the lower portion of the esophagus. The left lobe of the liver was replaced. Five grams of sulfanilamide powder were sprinkled into this area and a single cigarette drain placed just to the right of the esophagus. The wound was closed with No. 00 chromic catgut for the peritoneum, interrupted No. 40 cotton for the fascia, and No. 60 for the skin.

The wound healed per primam. Sterile water was given in small amounts after forty-eight hours and full liquids after ninety-six hours. Solid food was started on the ninth day, and the patient was discharged home on the thirteenth postoperative day. Prior to discharge fluoroscopy was done on the patient after a barium swallow, and it was seen to pass readily and easily into the stomach. There was still an increase in the diameter of the esophagus.

One month later, he had gained twenty pounds in weight, and on Nov. 5, 1944, his family physician reported that he was well, working daily, and weighed 240 pounds.

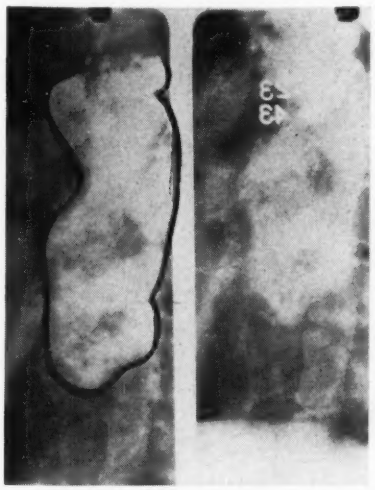


Fig. 3 (Case 1).—Preoperative x-ray view of the esophagus. Filling is poor due to presence of old food mixed with barium. The esophagus is outlined with a black line.

CASE 2.—C. B., a 23-year-old millworker, was referred by a bronchoscopist on Feb. 12, 1943, with a diagnosis of cardiospasm, for consideration of surgical therapy. At the age of 12, eleven years before admission, he noticed for the first time difficulty in swallowing food. He chewed food very slowly and thoroughly, but on attempting to swallow he found it difficult and had a sensation of something stopping in the lower portion of the chest directly beneath the sternum. He stood up, walked around trying to swallow, and drank water, hot tea, or coffee to try more forcefully to get food to pass through. At times even a glass of water could not be swallowed until he stood up and walked. Anything cold was much worse than warm food or drink. It had been impossible to eat ice cream for eleven years. The usual cold lunch was the most difficult, and finally the patient gave up even carrying lunch to work, depending upon a slowly eaten warm breakfast and supper. In October, 1942, the patient first sought medical aid, and from then until Feb. 12, 1943, he had dilatations every three to six weeks. Relief was not marked and never lasted more than two weeks and usually only about seven days.

The patient refused all invitations to dine out because of the difficulty in swallowing. For two days prior to examination he had been unable to drink much water. Vomiting of small amounts of undigested food eaten recently or sometimes twelve to twenty-four hours before occurred occasionally.

Past history was negative except for a history of poliomyelitis in childhood. He was very active in spirts, playing semiprofessional baseball and basketball. He tried to eat all types of food except cold things and used no alcohol or tobacco.

On examination the patient was a well-developed, thin, quiet, and cooperative young white man. There was slight atrophy of the musculature of the right lower leg but no paralysis nor demonstrable weakness. Weight was 126 pounds, height 70½ inches. Roentgenographic examination of the upper gastrointestinal tract showed marked cardiospasm, with the lower portion of the esophagus two inches in diameter. Barium passed into the stomach in extremely small amounts very slowly.

The patient found the frequent dilatations uncomfortable, distasteful, time-consuming, and expensive. A cardioplasty was advised, but the patient delayed admission to the hospital until June 2, 1943. On admission, the findings were the same as before except for a continued weight loss down to 116 pounds. Esophageal lavage brought up between 500 and 700 c.c. of food particles and liquid, morning and evening, for several days. On the morning of operation 250 c.c. of watery fluid were aspirated, after having nothing by mouth for seven hours and water only for six hours prior to that.

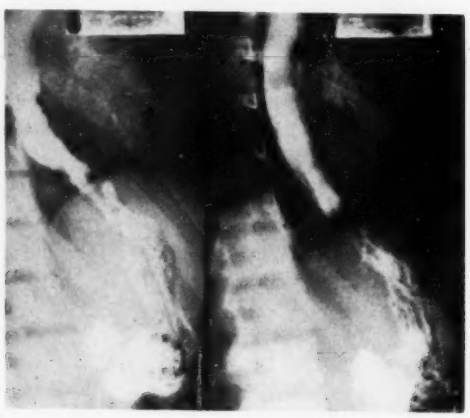


Fig. 4 (Case 2).—Roentgenogram taken eighteen months after esophagogastrostomy; the esophagus was narrow and emptied readily.

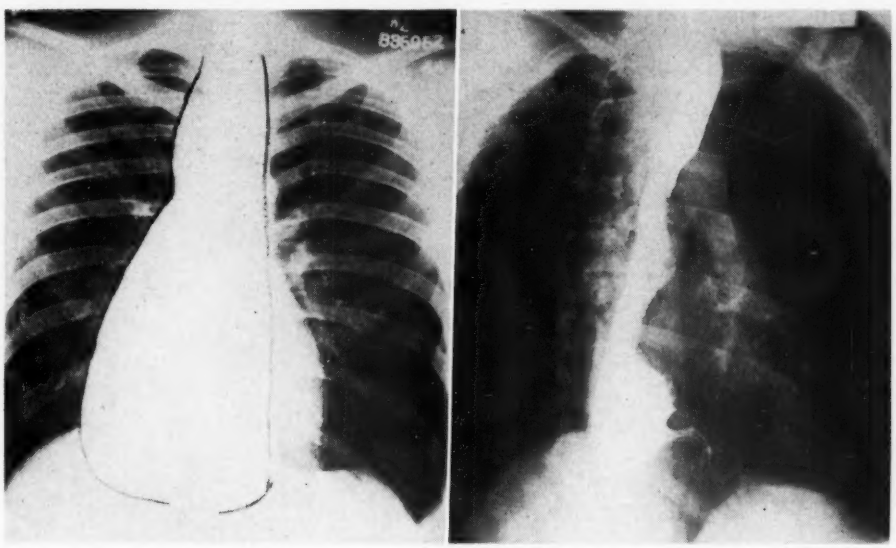
On July 4, an esophagogastrostomy was performed through a left upper rectus incision under avertin and nitrous-oxide-ether anesthesia. The thoracic cage was long and the costal flare very narrow, so that exposure was unusually difficult. The abdominal contents were normal. After cutting the suspensory ligament of the left lobe of the liver, the esophageal hiatus was found, the esophagus mobilized and pulled downward about 8 to 9 cm. A two-layer anastomosis was made in the manner shown in Fig. 2. Interrupted cotton sutures were used for the outer row of sutures and continuous No. 00 chromic catgut for the inner approximating suture. Five grams of sulfanilamide crystals were sprinkled loosely in and around the anastomotic area. The diaphragm was resutured to the esophagus about 1½ cm. above the anastomosis which had an opening 5 cm. in diameter. The liver was replaced in its normal position. The abdomen was closed with a continuous No. 00 chromic catgut for the peritoneum, interrupted No. 40 cotton sutures for the fascia, and interrupted No. 60 cotton sutures for the skin. A single cigarette drain was brought out of the upper angle of the wound.

The immediate postoperative course was uneventful except for a mild febrile reaction for three days. Sterile water was started by mouth after forty-eight hours, and clear liquids on the fourth day. A soft diet was given on the seventh day. Two days later the wound became puffy and red and was rather tender. There was no temperature elevation. The wound was opened slightly and 40 c.c. of yellowish-gray purulent material were evacuated. Culture of this showed *Staphylococcus albus* and mixed organisms. The wound healed slowly but completely, and he was discharged home on the twentieth postoperative day.

He gained weight slowly and returned to all usual activity in eight weeks. Several weeks later he was able to eat ice cream again. Roentgenograms on Dec. 1, 1944, showed a

large opening into the stomach with no delay in the passage of barium (see Fig. 4). On Nov. 1, 1945, his weight was 156 pounds, and he considered himself perfectly well.

CASE 3.—R. K., a 26-year-old white man, a clerk, was referred on Aug. 30, 1944, with a diagnosis of cardiospasm. His parents stated that, at the age of 10, he began to lose weight and from that time on was always thin and lacking in strength and energy. Intermittently he would regurgitate food immediately after eating. At times he felt too weak to continue work. Fluids were just as difficult to swallow as solid food during the last six months. Numerous attempts were made to dilate the cardia at several hospitals during the previous two years, and the patient was sent home to continue dilatations at home with a hydrostatic dilator. Many times it was impossible, and always it was very difficult to pass the dilator; at best relief was obtained for only seven to ten days. The past history was otherwise negative except for repair of an indirect inguinal hernia four years previously. Convalescence was uneventful.



A. *B.*

Fig. 5 (Case 3).—*A*, Preoperative study of esophagus; note flask shape. This esophagus measured 14 cm. in width. *B*, View of esophagus two weeks after esophagogastrostomy. There is still some dilatation, but barium passed into the stomach easily.

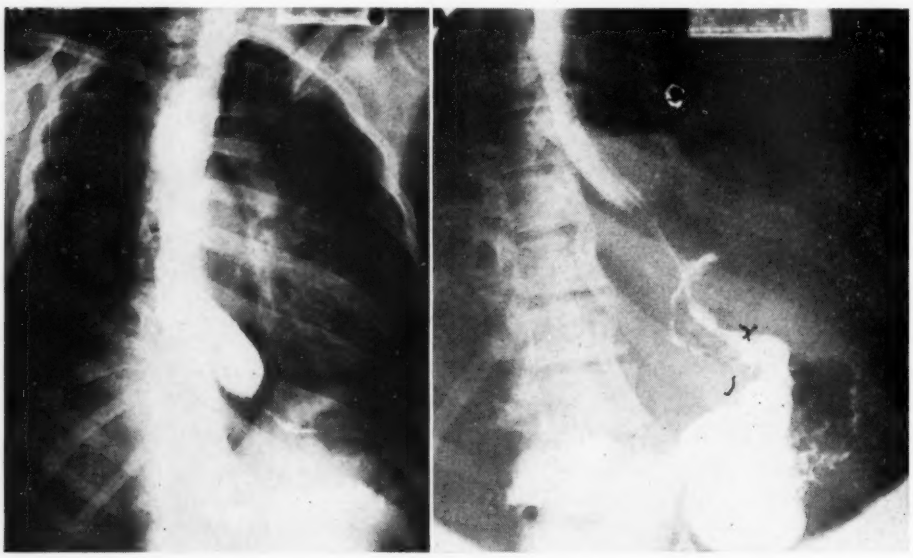
On physical examination, the patient was tall, thin, appeared dehydrated, and chronically ill. Height was 71 inches and weight 120 pounds. The blood pressure was 125 systolic and 80 diastolic. Routine blood and urine studies were negative. There was a well-healed left inguinal scar. All other findings were negative except for considerable widening of the retrosternal dullness. Previous reported roentgen ray studies showed a huge dilated sigmoid type esophagus which curved far out to the right side (see Fig. 5, *a*). There was no passage of barium into the stomach for about three hours. Slowly from then on, the barium passed through. The greatest diameter of the esophagus was 14 cm. as measured roentgenographically. A stomach tube was inserted six hours later, and 1½ pints of barium, old food, and mucous material was aspirated. A diagnosis of achalasia was made.

The esophagus was lavaged twice daily for several days.

On Sept. 2, 1944, an esophagogastrostomy was performed under continuous spinal anesthesia, supplemented by celiac plexus infiltration of 40 c.c. of 1 per cent novocain. The exposure and the procedure were the same as outlined in the other cases. The lower end of the esophagus was very narrow, measuring just 2 cm. in diameter, and the wall was very thick. A two-layer anastomosis was made, using interrupted cotton for the outer layer and

No. 000 chromic catgut for the inner layer. A single cigarette drain was brought out through a stab wound to the left of the incision, and closure was the same as used in the other cases.

The convalescence was uneventful. The drain was removed in four days, and the patient was ambulatory after the seventh day. He was started on water after two days and progressed to a normal diet on the tenth day, at which time he was discharged. Ten weeks later he returned for postoperative examination. The weight was 153 pounds, a gain of thirty-three pounds. The patient felt well, and his wife added that he had several times mentioned that he felt happy and contented since his operation, and that she had never heard him say this in their previous years of married life. Postoperative roentgenographs showed barium passing readily into the stomach, although all dilatation had not yet disappeared (see Fig. 5, *b*). In October, 1945, he reported that he was still feeling well and eating all foods normally.



A. *B.*

Fig. 6 (Case 4).—*A*, A sigmoid or hockey-stick type esophagus, with marked delay in the emptying time. This view was taken twenty minutes after swallowing the barium meal. *B*, X-ray picture made two weeks after esophagogastrostomy. There is some deformity of the cardiac end of the stomach, apparently due to inflammatory reaction in the left subdiaphragmatic area, but the esophagus empties readily.

CASE 4.—J. D., aged thirty-six years, a colored man, a truck driver, was first seen in consultation on Nov. 28, 1944, with a complaint of dysphagia of six to eight years' duration. Until two years before this occurred only in attacks or waves lasting three to seven days and often with a free interval of four to eight weeks. For the previous two years the dysphagia had been present all the time, although the degree fluctuated constantly. During this time, he would actually vomit most of the ingested food or liquid for a few days and then perhaps improve again. He had been unable to eat or drink anything cold for two years. He was unable to relate the attacks to any type of food, or to any factor in his work or home life. Roentgenograms previously made showed achalasia of the cardia and considerable dilatation and elongation of the esophagus. He was advised to have esophagoscopy and dilatations and returned to his home for this. On May 14, 1945, he returned worse than before, despite dilatations with a hydrostatic bougie approximately every fourteen days. He had lost fourteen pounds in weight and was regurgitating food from the noon and evening meals almost daily.

General examination was not remarkable. Blood and urine studies were negative. He seemed very phlegmatic throughout all the studies. X-ray examination showed a sigmoid type esophagus with considerable dilatation, and only a small trickle of barium passed through

the cardioesophageal junction, despite vigorous contraction waves. The barium stream passing through was about 3 mm. in diameter, and at the end of twenty minutes the esophagus was still very full (see Fig. 6, *a*).

On May 21, 1945, an esophagogastrostomy was performed, transabdominally, under spinal anesthesia. The exposure was difficult, and the stomach, despite frequent lavages, seemed rather full. There was some soiling of the operative field with this when the cardia was opened. Otherwise the usual procedure was carried out, and a drain was inserted through a stab wound on the left side. This was removed on the fourth day, after which the patient developed considerable fever and, on the tenth day, began to drain thick, foul purulent material from this stab wound, although the original incision, closed throughout with interrupted cotton, remained well healed. The fever subsided, but the drainage persisted intermittently for two months, during which time the postoperative x-rays were taken (see Fig. 6, *b*). These showed considerable spasm around the cardiac end of the stomach, but the anastomosis was functioning well. Therefore, on July 20, 1945, the left subdiaphragmatic region was explored posteriorly and, although no actual abscess could be found, drains were inserted, and within ten days all anterior drainage had ceased, and he was much improved. The posterior drains were removed, and the wound healed slowly. He was discharged on the twentieth postoperative day remaining well since that time.

SUMMARY

All patients with dysphagia and regurgitation should be carefully studied. Those which are due to idiopathic spasm of the cardioesophageal junction must be differentiated as to degree and type of secondary deformity of the esophagus. Drugs, careful slow eating, avoidance of emotional stress, and dilatations should be used. For patients with large, flask-shaped or sigmoid type of dilatation and for those who do not respond well to conservative therapy, esophagogastrostomy is indicated. A report of four cases selected according to these criteria is presented. They have been followed from six to thirty-five months and the patients appear well clinically and roentgenographically.

REFERENCES

1. Major, R. H.: Classic Descriptions of Diseases, Springfield, 1932, Charles C Thomas, p. 591.
2. Osgood, Hamilton: A Peculiar Form of Oesophagismus, Boston M. & S. J. **120**: 401-405, 1889.
3. Guisez, J.: A propos des sténoses congénitales de l'oesophage, Clinique, Paris **34**: 163-165, 1939.
4. Walton, A. J.: The Surgical Treatment of Cardiospasm, Brit. J. Surg. **12**: 701-737, 1925. 1925.
5. Von Mikulicz, J.: Zur Pathologie und Therapie des Cardiospasmus, Deutsche med. Wchnschr. **30**: 17, 1904.
6. Gray, Howard K., and Skinner, Ira C.: The Operative Treatment of Cardiospasm, J. Thoracic Surg. **10**: 220-235, 1940.
7 Alvarez, W. C.: The Mechanics of the Digestive Tract, Ed. 2, New York, 1928, Paul B. Hoeber, Inc., pp. 82-93.
8. Comby, J.: Pharyngisme et esophagisme chez les enfants, Arch. de méd. d. enf. **23**: 247-250, 1920.
9. Jacobson, Edmund: Spastic Esophagus and Mucous Colitis: Etiology and Treatment by Progressive Relaxation, Arch. Int. Med. **39**: 433-445, 1927.
10. Muggia, Alberto: Spasmo dell'esofago e Tetania nel Lattante, Lattante **1**: 524-526, 1930.
11. Bruhl, H.: Der kindliche Oesophagospasmus, Ztschr. f. Laryng., Rhin., Otol. **21**: 1, 1931.
12. Sudhues, Maria: Über den Speiseröhrenkrampf beim Kinde, Arch. f. Kinderh. **96**: 65-88, 1932.
13. Weiss, Edward: Cardiospasm: A Psychosomatic Disorder, Psychosom. Med. **6**: 58-70, 1944.

14. Ochsner, Alton, and DeBakey, Michael: The Surgical Treatment of Achalasia of the Oesophagus, Surg., Gynec. & Obst. **72**: 290-295, 1941.
15. Schmidt, Herbert W.: Diffuse Spasm of the Lower Half of the Esophagus, Am. J. Digest Dis. **6**: 693-700, 1939.
16. Heyrovsky, H.: Casuistik und Therapie der idiopathischen Dilation der Seiseroehre, Oesophago-Gastroanastomose, Arch. f. klin. Chir. **100**: 703, 1913.
17. Vinson, Porter C.: Cardiospasm, Am. J. Surg. **56**: 79-85, 1942.
18. Jaffie, K.: Ueber idiopathische Oesophaguserweiterung, München. med. Wchnschr. **44**: 386, 1897.
19. Freeman, L.: An Operation for Relief of Cardiospasm Associated With Dilatation and Tortuosity of the Esophagus, Ann. Surg. **78**: 173-175, 1923.
20. Heller, E.: Extramukoese Cardioplastik beim chronischen Cardiospasmus mit Dilatation des Oesophagus, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **27**: 141, 1914.
21. Womack, N. A.: Esophagoplasty for Esophageal Achalasia, S. Clin. North America **18**: 1241-1254, 1938.
22. Finney, J. M. T.: A New Method of Pyloroplasty, Bull. Johns Hopkins Hosp. **13**: 155, 1902.
23. Häggström, P., quoted by Sturtevant, M.: Cardiospasm; With a Review of the Literature, Arch. Int. Med. **51**: 714-736, 1933.
24. Kredel, Frederick E.: Surgical Treatment of Cardiospasm, South. Med. & Surg. **104**: 258-259, 1942.
25. Sprunt, W. H., and Harrill, J. A.: Cardiospasm, North Carolina M. J. **5**: 238-241, 1944.
26. Wachs, E.: Ueber Methoden der Kardiospasmusbehandlung und ihre Erfolge, Arch. f. klin. Chir. **200**: 259-266, 1940.
27. Grimson, K. S., Taylor, H. M., Trent, J. C., Wilson, D. A., and Hill, H. C.: The Effect of Transthoracic Vagotomy Upon the Functions of the Stomach and Upon the Early Clinical Course of Patients With Peptic Ulcer, South. M. J. **39**: 460-470, 1946.
28. Grondahl, J. W., and Haney, H. F.: An Attempt to Produce Experimental Cardiospasm in Dogs, Proc. Soc. Exper. Biol. & Med. **44**: 126-129, 1940.
29. Knight, G. C.: The Relation of the Extrinsic Nerves to the Functional Activity of the Esophagus, Brit. J. Surg. **22**: 155-168, 1934.
30. Knight, G. C., and Adamson, W. A. D.: Achalasia of Cardia, Proc. Roy. Soc. Med. **28**: 891-897, 1935.
31. Knight, G. C.: Sympathectomy in the Treatment of Achalasia of the Cardia, Brit. J. Surg. **22**: 864-876, 1935.
32. Douthwaite, A H.: Achalasia of Cardia; Treatment With Nitrites, Lancet **2**: 353-354, 1943.
33. Moersch, Herman J.: Cardiospasm, Its Diagnosis and Treatment, Ann. Surg. **98**: 232-238, 1933.
34. Hoover, Walter B.: Cardiospasm: An Analysis of Twenty-five Consecutive Cases, S. Clin. North America **23**: 827-829, 1943.
35. Lambert, A. U. S.: Treatment of Diffuse Dilatation of the Esophagus by Operation, Surg., Gynec. & Obst. **18**: 1, 1914.
36. Rake, G. W.: On the Pathology of Achalasia of the Cardia, Guy's Hosp. Rep. **77**: 141-150, 1927.

SURGICAL REMOVAL OF LARGE RETROPERITONEAL LUMBAR GANGLIONEUROMA

A Case Report

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ATTENTION was first called to the unusual tumor described in this article by the case report of Loretz[1] in 1870. Although it was a mediastinal ganglioneuroma found at autopsy, it was the first time that this tumor was described as a separate entity. Prior to that time all such tumors were classified with the neuromas. For the next eighteen years not a single tumor of this type was reported. It was not until 1898 that the next report of a ganglioneuroma appeared in the literature. This was a report of a retroperitoneal pelvic ganglioneuroma by Busse.[2] Since then, however, the stream of case reports describing this unusual type of tumor has been steady, until at the present time about 200 cases of authenticated ganglioneuroma throughout the body have been reported. McFarland,[3] in 1931, reported a case and surveyed the literature very carefully. He tabulated all the cases reported to date as to location in the body. A glance at his survey of the literature readily discloses the fact that a ganglioneuroma can and often does arise in almost any part of the body. The only necessary antecedent to the development of this tumor is the presence of misplaced neurocytes. As a result we find ganglioneuromas in the central nervous system, in the crainial nerves, roots or ganglia, in the neck, in the thorax, in the gastrointestinal tract, in the adrenal, in the pelvis, retroperitoneal, and peripherally, as even in the knee. The lumbar type of retroperitoneal ganglioneuroma appears to be one of the uncommon sites of origin of this tumor. In McFarland's survey of the literature, he listed thirty-two reports of retroperitoneal ganglioneuromas. Because of World War II, it has been impossible at this time to obtain copies of case reports from the Japanese, Russian, Czechoslovakian, and Italian literature which are listed in the *Quarterly Cumulative Index Medicus* as reporting one to two cases in each language. For this reason, if we accept the cases reported in these languages, the total number of retroperitoneal lumbar cases reported is somewhat less than fifty. Many of these patients were operated upon, although some of the tumors in this location were found incidental to autopsy. Among those operated upon, many of the patients died and in many the tumor could not be completely removed due to its fixity to the aorta, iliac arteries, or ureter. All surgeons stress the great difficulty in removing these tumors not only because of their proximity to great vessels, but also because of the great vascularity in the tumor itself. The collapse (circulatory) of the patient either during or after the operation was a very common accompaniment of this type of surgery. In Kehrer's[4] report, the iliac artery was torn and the patient died;

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in von Salacz's report[5] the common iliac artery required suture and the patient died; King[6] and also Evans and Francona[7] in their case reports stressed the fact that the patients operated upon so often went into shock.

The consensus of opinion at the present time is that these tumors are congenital in origin. They are thought to arise from cells that were displaced or miscarried during the migration of the ganglionic crests during embryonic life. In man and higher mammals, the sympathetic ganglion organization[8] is the result of a migration of individual cells from the neural crest substance down the dorsal nerve roots and peripheral trunks to form paired ganglionic clusters dorsolateral to the aorta. As early as 5 mm. embryo (five weeks), these sympathetic primordia can be found throughout most of the extent of the trunk dorsolateral to the aorta. These cells may never reach the ganglionic mass and may become arrested or displaced anywhere along the way. Such cell rests may remain quiescent forever and never give rise to any difficulty, or they may begin to proliferate at any period of antenatal or postnatal life. The type of tumor that is formed by these cells depends upon the level of differentiation that has been attained before neoplastic development took place. Since these primordial cells become differentiated to neurocytes which then develop into neuroblasts or pheochromoblasts, and ultimately develop into ganglion cells and pheochromocytes, it becomes quite evident that theoretically five different types of tumor would be possible. Actually, however, only three types of tumors arise from the neurocytes. These are neuroblastoma, pheochromocytoma, and ganglioneuroma. Pheochromoblastoma and neurocytoma have not been described in the literature as yet. Of the three tumors that have been described in the literature, the ganglioneuroma represents the neoplastic development of the mature cell, or rather the neoplastic development after the neurocyte has reached the end stage of its development. Of these three types of tumor, only the ganglioneuroma lacks clinical characteristics permitting the clinician to make a diagnosis. The rapidly growing tumors, usually found in the renal area of children under 4 years of age, are highly suggestive of a neuroblastoma to the clinician, and the presence of a tumor mass in the renal area associated with paroxysmal hypertension[9] is almost pathognomonic of a pheochromocytoma. From the clinician's point of view, the only characteristic feature of the ganglioneuroma is the presence of a large tumor mass with a complete absence of characteristic clinical features. The tumor may be present for many years without producing any symptoms. In the case report of von Salacz, the tumor had been present for fourteen years that the patient was aware of without producing any clinical symptoms whatever. It is this one feature that we believe could help the clinician to arrive at a presumptive diagnosis of ganglioneuroma. That is, the presence of a soft or moderately firm tumor of oval shape and large size, situated to one side of the midline, fixed posteriorly, and present for years without producing symptoms.

Although textbooks[10] and most articles call this tumor a pathologically benign one, nevertheless, there have been case reports indicating that it may

become malignant.[11] Malignant degeneration of the ganglioneuroma must be exceedingly rare, however, judging from these few isolated case reports.

Although the tumors are usually single, there have been two case reports of multiple ganglioneuromas.

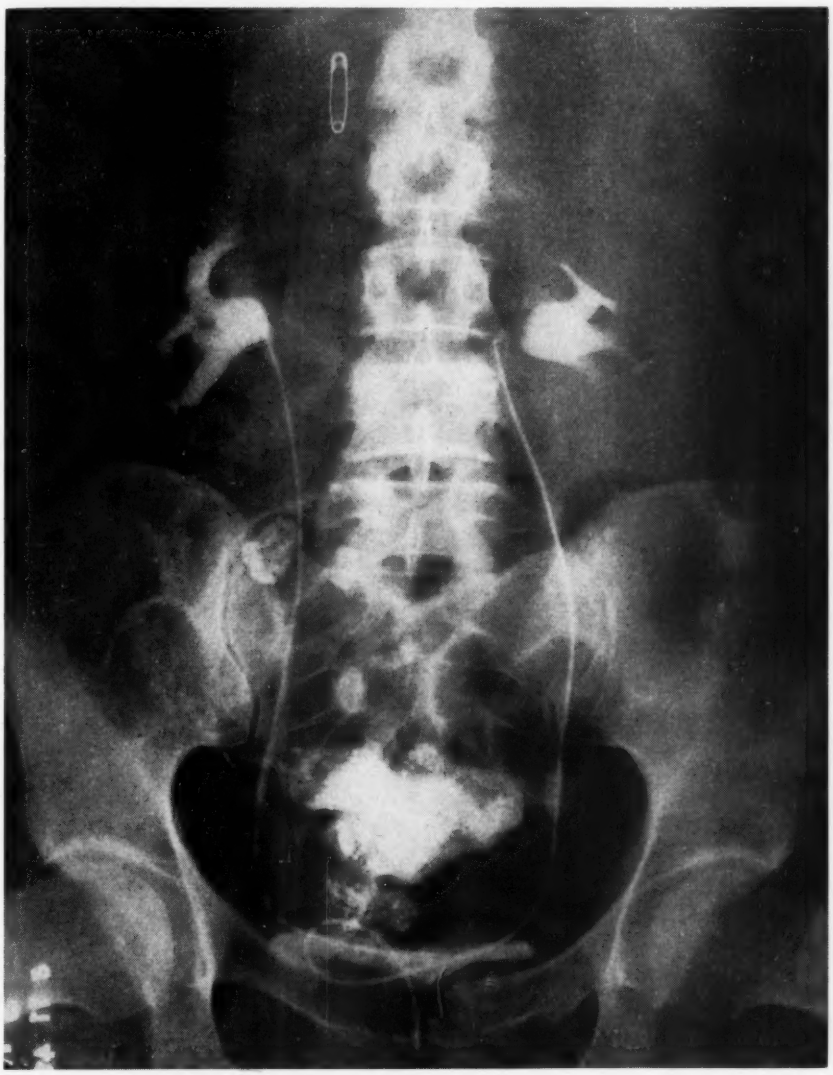

Fig. 1.—Note that the left kidney has been distorted by the presence of the ganglioneuroma; note the depression of the calyces at the upper pole.

The case we are reporting includes all the characteristic features of a ganglioneuroma, namely, the presence of an asymptomatic tumor of large size in the left renal area, displacement of the left kidney with distortion of the pyelogram (see Fig. 1) without invading the kidney, extreme vascularity of the tumor, and its difficulty in removal.

CASE REPORTS

G. T., a 55-year-old white woman, was admitted to the Grace Hospital complaining of "gas pains" and a mass in the left side. The patient had been complaining of "gas pains" over the abdomen on the left side for some years. The pain radiated to the back on the left side. She had nausea at times but never vomited. She had been constipated for many years. Past history was entirely negative. Upon examination, the patient was found to be a middle-aged white woman; she lay easily in bed and did not appear acutely ill. Temperature was 99° F., pulse 72, and respirations 20. Examination of head and neck showed no abnormality. Heart was normal in size and position. There were no murmurs; rate and rhythm were normal. There were no dropped beats. Blood pressure was 140/80. Lungs were resonant to percussion. Tactile fremitus was normal. There was bronchovesicular breathing. No râles. Abdomen revealed no distention or rigidity. There was no fluid wave or shifting dullness. A large, firm, nontender mass was easily palpable in the left hypochondrium. It did not move with respiration and appeared fixed deeply. Extremities were normal, reflexes, negative.

Laboratory examination revealed blood type 4; hemoglobin 10.2 Gm. (63 per cent); red blood count, 3,230,000; white blood count, 13,200; polymorphonuclears, 87 per cent; filament, 75 per cent; nonfilament, 12 per cent; lymphocytes, 12 per cent; monocytes, 1 per cent. Urine was amber, clear, and alkaline. Specific gravity was 1.019; albumin, negative; sugar, negative; sediment; occasional epithelial cell. Reticulocytes were 0.4 per cent. Coagulation time was 3¾ minutes; prothrombin time, 65 per cent; bleeding time, 1 minute. Skin test for undulant fever gave negative results, as did the agglutination test for typhoid, paratyphoid, and malta fever. Blood cholesterol was 115 mg.; nonprotein nitrogen, 25.5 mg.; whole blood chlorides, 528 mg. Examination of urine obtained from kidney pelves revealed, left kidney: white blood cells, few; red blood cells few; cast, negative; smear, negative; culture, staphylococcus; acid-fast, negative. Right kidney: white blood cells, few; red blood cells, none; casts, negative; smear, negative; culture, staphylococcus; acid-fast, negative. Stool examination showed hard stool, medium brown; occasional red and white blood cells.

On May 11, 1945, cystoscopy was carried out on the patient. It was found that, using a nupercaine 1:500 anesthetic, a No. 21 cystoscope passed easily into the bladder. The bladder mucosa was within range of normal and the bladder capacity was normal. No stone, diverticula, or trabeculations were seen. Both ureteral orifices were normally placed. The right was normal in appearance and function, the left slightly reddened in appearance. No. 5 catheters passed 25 cm. into either ureteral orifice without obstruction. Divided urines collected and intravenous indigo carmine appeared on the right in good concentration in five minutes and on the left in fourteen minutes. However, the concentration was good on the left after appearance and it is questionable whether the delay in appearance was due to obstruction at the catheter tip. Bilateral pyelograms were made with the patient in the flat and upright positions as well as in the lateral position.

By roentgen examination (retrograde pyelogram) both kidneys appeared to be normal in size and shape; both of them were somewhat ptosed. The one on the left appeared to be depressed at its superior pole by a large soft tissue mass noticed in the left upper quadrant. This was in all likelihood a large spleen. Calcified mesenteric glands were noted in the region of the right sacral wing. Psoas muscles were clearly visualized and appeared to be normal. No evidence of a urinary tract stone was noted. Catheters had been introduced into the kidney pelvis on the right and ureteropelvic junction on the left. Opaque dye was injected by the instrumental method and a normal outline of the right urinary tract was obtained while upper calyx and infundibula appear to be somewhat depressed, on the left, by outside pressure from the previously described soft tissue mass—thought to be an enlarged spleen. The conclusion was essentially normal bilateral instrumental pyeloureterography with depression of upper left renal lumina by an enlarged spleen.

Barium enema, on initial fluoroscopic review of the chest and abdomen, detected no evidence of grossly pathologic conditions in these areas. The barium enema was given under fluoroscopic control, without undue difficulty, and filled a rather redundant colon which

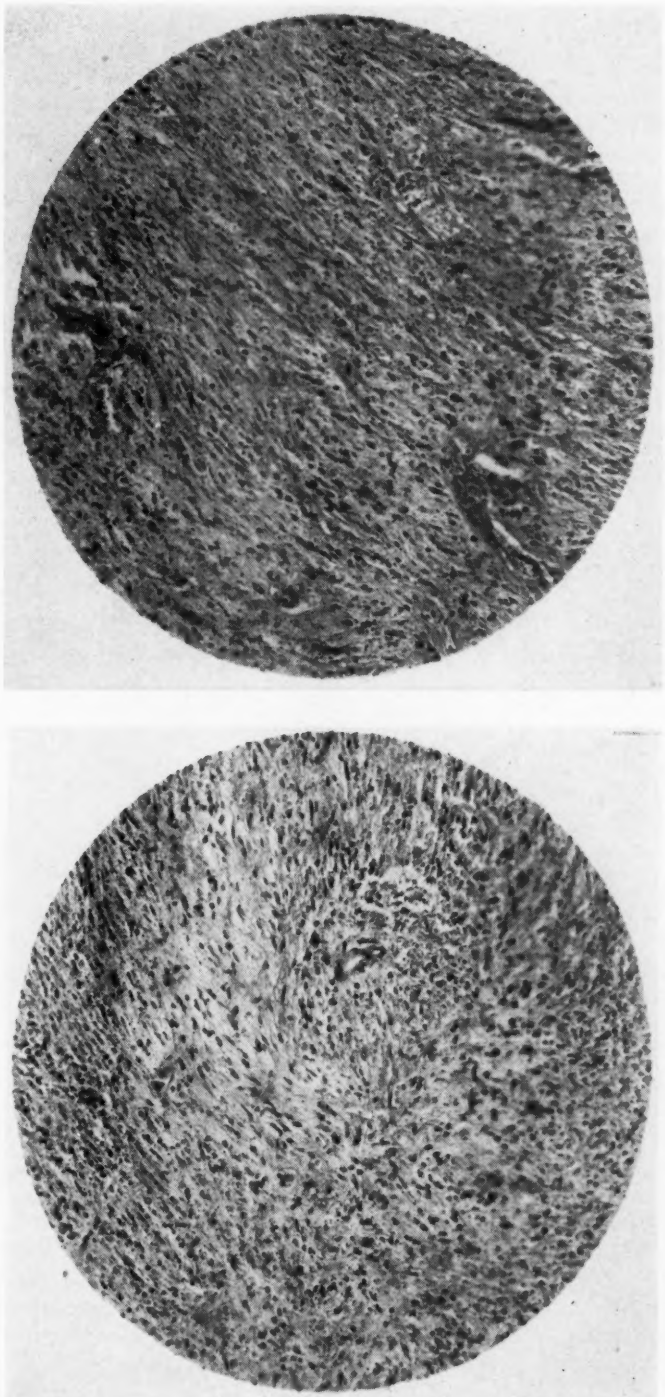

Fig. 2.—Note the nerve fibers throughout the section.

otherwise appeared to be normal. Roentgenograms were obtained before and after partial expulsion of the contrast clysma. These readily confirmed the fluoroscopic impressions. The conclusion was markedly redundant colon.

Cholecystogram revealed a normal gall bladder with no evidence of calculi. A somewhat irregularly shaped mixed opaque and radiopaque, somewhat oval shadow was noted to be lying just lateral to the right transverse process of the fifth lumbar vertebra, superimposing the wing of the ilium and probably representing a calcified mesenteric gland although the possibility of it being due to undissolved gall bladder dye cannot be ruled out from this examination alone.

On May 15, 1945, a sternal bone marrow puncture was performed. Examination of this marrow revealed promyelocytes 3 per cent, neutrophile myelocytes 14 per cent, neutrophile metamyelocytes 12 per cent, neutrophile stab forms 27 per cent, filamented forms 27 per cent, eosinophiles 1 per cent, eosinophilic myelocytes 1 per cent, lymphocytes 2 per cent, orthochromic normoblasts 6 per cent. The impression was hypoplastic for myeloid and erythroid elements.

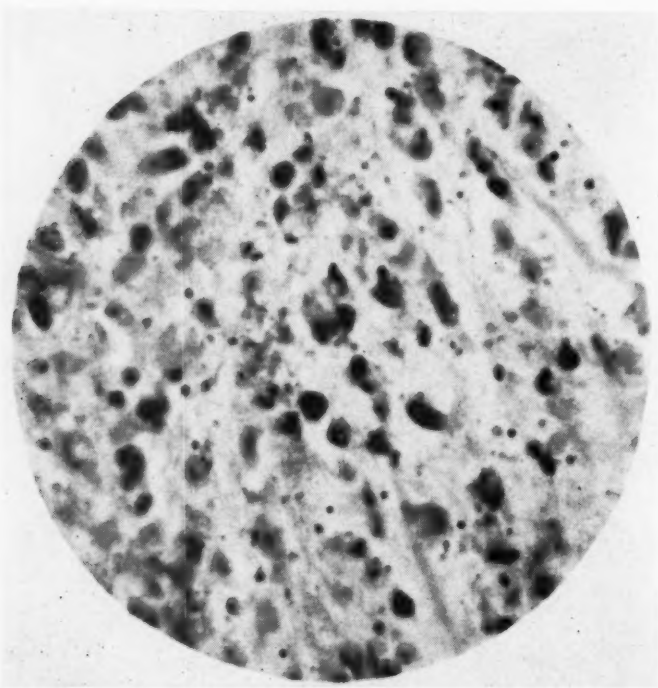

Fig. 3.—Note the atypical ganglion cells; the entire tumor consisted of myelinated and nonmyelinated nerve fibers and these atypical ganglion cells.

The patient was taken to the operating room on May 23, 1945. Under continuous spinal anesthesia, a transverse incision was made on the left side, one inch above the umbilicus, cutting across the rectus sheath and muscles. The abdomen was opened. A large mass was present in the left upper quadrant of the abdomen lying retroperitoneally with the descending colon and splenic flexure fastened above it. It was readily seen to be impossible to remove the mass through this incision, therefore a vertical incision was made along the edge of the rectus muscle from this incision. This gave wide exposure to the entire left side of the abdomen. The tumor was felt to be above the left kidney. It had pushed down below the umbilicus. An incision was now made twelve inches in length on the outer peritoneal surface. The descending colon and transverse colon were then separated from the tumor and pushed toward the midline. The tumor was then shelled out from its bed situated just above the left kidney and intimately attached to the bare area on the spleen just below the splenic ligament.

When separating the tumor mass from the spleen, the splenic artery was damaged and severe hemorrhage occurred. This necessitated clamping the splenic artery and vein and removing the spleen. The splenic artery and vein were ligated with a silk ligature. The tumor was then readily removed. There was added amount of oozing from the retroperitoneal space which was readily controlled with three abdominal packs. These were removed and the retroperitoneal space closed by sewing together the incision in the peritoneum. Two Penrose drains were left in the cavity and brought out through the incision. The wound was then closed in layers. For closure, continuous chromic was used to the peritoneum, interrupted No. 32 stainless steel wire to the fascia, skin clips for the skin.

The patient was given four transfusions of 500 c.c. of whole blood each, during the postoperative period. Convalescence was smooth, and the patient was discharged as cured on the eleventh postoperative day.

Pathologic report revealed that grossly the specimen consisted of a large tumor mass measuring 18 by 15 by 12 cm. The serosal surface of the mass was bluish gray in color. It was rough and covered with numerous fine adhesions. The mass was lobulated and well encapsulated. The capsule measured 2 mm. in thickness. On section, the tumor was found to be made up of tissue which varied markedly in color and consistency in different areas. In some areas, it was cartilaginous and pinkish red. In others, it had an orange color and in still other areas it was yellow and soft and edematous in consistency. Microscopic examination showed the tumor mass to be made up of nerve tissue of three different types. One type of nerve tissue found was the myelinated nerve fibers. The other type found was unmyelinated nerve fibers (see Fig. 2). In addition to the myelinated and unmyelinated nerve fibers, there were a number of atypical ganglion cells (see Fig. 3). The new growth did not appear to be malignant. Diagnosis was ganglioneuroma.

SUMMARY

The case report exemplifies the cardinal features of this uncommon interesting tumor. In the past, none of these tumors were diagnosed either preoperatively or during the life of the patient. With the clinical data that have been accumulating, however, we believe that a presumptive diagnosis, at least, could be made in these cases. The great value of such a diagnosis lies in the fact that the treatment is entirely surgical. Since malignant degeneration is very rare, it is only necessary to remove the tumor completely to cure the patient effectively. Here again, the surgeon must realize that one of the characteristic features of the tumor is its fixity to circumjacent structures, particularly large vessels, and the marked vascularity of the tumor itself. All patients must be adequately prepared preoperatively with whole blood transfusions, and must be given blood both during and after the operative removal. Furthermore, the great tendency of these patients to go into shock during and shortly after the operation must be taken into consideration and measures to counteract this taken immediately. In those cases in which the tumor can be completely removed, the patient is cured.

CONCLUSIONS

1. The characteristic feature (clinically) of a ganglioneuroma is the presence of a large tumor for many years without any clinical symptoms whatever.

2. The tumors are very difficult to remove because of their vascularity and adherence to circumjacent structures.

3. Patients who have retroperitoneal tumors, of this type, removed show a great tendency to go into shock during or shortly after operation.

4. If the tumor is completely removed, the patients are cured since malignant degeneration is rare.

REFERENCES

1. Loretz, W.: Ein Fall von gangliösem Neurom, Arch. f. path. Anat. [etc.], Berl. **49**: 435-440, 1870.
2. Busse, A.: Ein grosses Neuroma Gangliocellare des Nervus sympathicus, Virchow's Arch. f. path. Anat. [etc.], Berl. (Supplement) **151**: 66, 1898.
3. McFarland, J.: Ganglioneuroma of Retroperitoneal Origin, Arch. Path. **11**: 118-124, 1931.
4. Kehrer, E., reported by Clayton, S. G.: Case of Retroperitoneal Pelvic Ganglioneuroma, J. Obst. & Gynaec. Brit. Emp. **51**: 44-48, 1944.
5. von Salacz, P.: Retroperitoneales Ganglionneurom, Ovarialgeschwulst vortäuschend, Zentralbl. f. Gynäk. **60**: 1171-1178, 1936.
6. King, E. S. J.: Ganglioneuroma of the Suprarenal Gland, Australian & New Zealand J. Surg. **13**: 123-128, 1943.
7. Evans, J. H., and Francona, N. T.: Surgical Removal of Large Retroperitoneal Sacrolumbar ganglioneuroma, Am. J. Surg. **48**: 675-680, 1940.
8. Arey, L. B.: Developmental Anatomy, Philadelphia, 1937, W. B. Saunders Company, pp. 440-441.
9. E. C. Baumgarten, and Cantor, M. O.: Pheochromocytoma of the Adrenal, Ann. Surg. **3**: 112-116, 1940.
10. Boyd, W.: Text-Book of Pathology, Philadelphia, 1938, Lea and Febiger, p. 326.
11. Evans, J. H., and Francona, N. T.: Surgical Removal of Large Retroperitoneal Sacrolumbar Ganglioneuroma, Am. J. Surg. **48**: 675-680, 1940.

Review of Recent Meetings

REPORT OF THE 1946 MEETING OF THE SECTION ON SURGERY, GENERAL AND ABDOMINAL, OF THE AMERICAN MEDICAL ASSOCIATION

ROBERT R. LINTON, M.D., BOSTON, MASS.

THE Surgical Section of the American Medical Association convened in the auditorium of the War Memorial Opera House in San Francisco on the morning of Wednesday, July 3, 1946. The chairman, **Daniel C. Elkin**, Atlanta, Ga., presided and **Alton Ochsner**, New Orleans, La., served as secretary.

Thomas B. Aycock and **James W. Hendrick**, Baltimore, Md.: **The Problem of Phlebothrombosis and Thrombophlebitis.**—The differentiation between phlebothrombosis and thrombophlebitis was stressed. It was pointed out that the symptoms of phlebothrombosis are often mild. The condition may occur in either medical or surgical patients. The source of pulmonary emboli as a rule is in the calf or plantar veins. Interruption of the femoral vein was recommended. The symptoms of thrombophlebitis are more pronounced but pulmonary emboli are less common. Paravertebral procaine injection of the lumbar ganglia, supplemented with bromsalizol, was recommended. It was reported that this treatment relieves the pain, reduces the temperature, and causes the edema to disappear with little or no permanent fibrosis.

Leo Loewe and **Edward Hirsch**, Brooklyn, N. Y.: **Heparin in the Treatment of Thromboembolic Disease.**—The subcutaneous administration of heparin in the Pitkin menstruum was reported as a safe, simple, practical, and effective method for the treatment of thromboembolic disease, based on the results of observations in more than 200 cases. Four deaths were reported from fatal pulmonary embolism in this group. Experimental studies were carried out on the jugular veins in rabbits. These studies revealed, according to the authors, that heparin had a definite lytic effect on intravascular thrombosis produced by mechanical means. The authors believe that their experiment indicated that heparin increased the collateral venous return following interruption of the jugular vein in rabbits.

Arthur W. Allen, Robert R. Linton, and **Gordon A. Donaldson**, Boston, Mass.: **Venous Thrombosis and Pulmonary Embolism: Comparative Study of Femoral Vein Interruption and Dicumarol Therapy.**—Up to June 1, 1946, 1,300 patients were subjected to femoral vein interruption for the treatment of deep venous thrombosis and the prevention of pulmonary embolism at the Massachusetts General Hospital. No fatal complications resulted from the procedure. Six patients, who had had previous infarcts with diminished vital capacity, finally had sufficient additional emboli to cause death, but there was no case of sudden massive pulmonary embolus following bilateral femoral vein interruptions in these 1,300 patients. Prophylactic bilateral femoral vein interruptions were done in 357 patients. This procedure was recommended in patients over the age of 65 years subjected to major abdominal surgery for carcinoma. Controlled studies were carried out on a group of patients between the ages of 40 and 65 years, subjected to major surgical procedures, with small doses of dicumarol postoperatively to determine whether or not it would reduce the incidence of postoperative venous thrombosis. It was found that the incidence was reduced to 25 per cent of that seen in an untreated comparable group. Femoral vein interruption surprisingly produced little if any effect on the venous return from the legs. In none of the 1,300 patients was any serious sequelae noted, other than one chronic ulcer of the lower leg.

Received for publication, July 30, 1946.

Geza de Takats, Chicago, Ill.: **Sympathectomy for Peripheral Vascular Sclerosis.**—A group of fifty-seven patients, suffering from vascular sclerosis of the lower extremities, was reported. Lumbar sympathectomy was performed if, after preliminary block of the lumbar sympathetics, the temperature of the digits rose, if walking ability improved, and if generalized vascular involvement was not too extensive. It was felt that the operation resulted in dramatic increase in walking ability in one group; amputation was averted in a second group; amputation could be performed at a lower level in a third group; and intractable neuritic pain of the causalgia type was improved in a fourth group. Good results were reported in fifty-three cases; four were unsuccessful.

E. Craig Heringman, James D. Rives, and **Harry A. Davis**, New Orleans, La.: **The Evaluation of Operative Procedure for Repair of Arteriovenous Fistulas: Statistical Analysis of 53 Cases.**—Fifty-three cases of arteriovenous fistulas were reviewed. The accepted methods of surgical treatment of arteriovenous fistulas were utilized in these cases. An analysis showed that transvenous restorative procedures were followed by significantly fewer cases of vascular insufficiency than when quadruple ligation or obliteration of the main artery was carried out. It was stressed that each patient should be carefully considered before deciding on which method should be used. Restoration of the continuity of the main artery was recommended as the operation of choice, since it was followed by the least evidence of vascular insufficiency.

E. S. Gurdjian and **J. E. Webster**, Detroit, Mich.: **Newer Concepts in the Mechanism and Management of Head Injury.**—The mechanism of head injury was analyzed on the basis of recent work with electronic strain gauge measurement of deformations of the skull and study of changes in intracranial pressure detected by electrical means. Experimental animals were used to study the paths of strain following a blow of known quantity of energy. From a study of human fracture lines seen in roentgenograms, one may venture a guess concerning the area of impact at the time of accident. The management of head trauma was reported on the basis of lessons learned from researches into the chemistry of the brain following acute head injury.

Ralph Herz, Cleveland, Ohio: **Herniation of Subfascial Fat as a Cause of Low Back Pain: Results of Surgical Treatment.**—Severe pain in the back was reported to have been relieved in thirty-seven patients by the surgical removal of a herniated mass of subfascial fat in the lumbar region. The diagnosis was confirmed by injection of procaine solution around the mass. Sudden strain apparently precipitates the herniation of fatty tissue, which then becomes edematous causing pressure, which may lead to severe back pain. Of the thirty-seven cases reported, thirty-four patients were completely relieved six months to three years following the operation.

Thursday, July 4: Election of Officers for 1947

Chairman's Address: **Daniel C. Elkin**, Atlanta, Ga.: **Exposure of Blood Vessels.**—A review of the exposure of the major blood vessels of the body was presented. The material for this presentation was obtained by the work carried out by the author at the Ashford General Hospital Vascular Center, White Sulphur Springs, Va., on soldiers from World War II suffering from injuries to major blood vessels secondary to missiles. An excellent description of the operative exposures for the major blood vessels of the upper extremity, neck, thorax, and lower extremity was given. The exposure of arteriovenous fistulas involving the posterior tibial and peroneal arteries, and utilizing the subperiosteal resection of the proximal portion and head of the fibula was of outstanding interest as a new approach to vascular lesions involving these vessels.

Francis D. Moore, William P. Chapman, Chester M. Jones, and **Milford D. Schulz**, Boston, Mass.: **Transdiaphragmatic Vagus Resection in Peptic Ulcer: Physiologic Effects**

and Early Results.—The results obtained on forty selected cases of duodenal and jejunal ulcers treated during the past two years by transthoracic vagus resection were reported from the Massachusetts General Hospital. Many of the group had been subjected to surgical intervention prior to this procedure. Seven had jejunal ulcers and seven had bled in the past, two massively. In the short time since the operation on these patients, good symptomatic results with healing of the ulcers have been demonstrated. One patient failed to respond to the operation, in which the antrum of the stomach was still present following a sleeve resection of the mid-portion of the stomach and a gastrojejunostomy. The physiologic observations carried out on these patients revealed a decreasing motility of the stomach with a diminished secretion but no change in the threshold of gastric sensation to the stimulus of balloon distention.

Richard B. Cattell, Boston, Mass.: **Benign Strictures of the Bile Ducts.**—An analysis of 123 benign strictures of the bile ducts was reported. Operative injury was responsible for 99. Repair of the common duct with end-to-end suture of the proximal and distal segments was stressed as the best method of repair, avoiding anastomosis to the gastrointestinal tract wherever possible. It was recommended that the anastomosis be done over a T tube, bringing the long arm out through a separate wound in the common duct distal or proximal to the end-to-end suture line.

Everett I. Evans, Richmond, Va.: **The Early Recognition and Management of Intestinal Strangulation.**—The differential diagnosis between simple and strangulation obstruction, based on the clinical signs and symptoms in seventeen patients with strangulation obstruction seen by the author, was reported. The clinical phenomena utilized in the diagnosis are the manner of onset of pain, a new sign, "position of relief," auscultation, and shock picture. The importance of early diagnosis and early surgical relief by operation was especially stressed, as it is only possible to reduce mortality in this manner.

Harry E. Bacon and **Lowrain E. McCrea,** Philadelphia, Pa.: **Abdominoperineal Proctosigmoidectomy for Rectal Cancer and the Management of Associated Vesical Dysfunction.**—The basis of this report was 430 patients with rectal and sigmoidal cancer. Operation was performed in 392, resection in 345. "Proctosigmoidectomy" was performed in 223 instances with division but preservation of the sphincter muscles with 85 per cent of continence; without division, 95 per cent. A mortality of 6.2 per cent was reported, 14 deaths in 223 patients. The rates of survival were 58.6 per cent for three years and 50.0 per cent for five years. Impotence by this type of operation was reduced, as compared to the Miles abdominoperineal resection; it was 55.5 per cent when the sphincters were divided and 8.3 per cent when the sphincters were not divided.

Paul C. Blaisdell, Pasadena, Calif.: **Unique Behavior of the Healing Open Pilonidal Wound and Clinical Complications.**—The characteristics of the different components of the healing of pilonidal wound were discussed. The causes of delayed healing, their prevention and treatment were included. A simple and effective acceleration of average healing time, the unrecognized relation of delayed healing and recurrence, and the misunderstood role of injection were discussed. No comparative evaluation of the method was attempted; the aim of the paper was to clarify basic facts related to the problem.

Friday, July 5: Symposium on Wound Management

John D. Stewart, Buffalo, N. Y.: **Wound Shock.**—The clinical picture of wound shock, as seen in the gravely wounded battle casualty, was discussed along with the causative factors. Reduction in blood volume per se, due to hemorrhage and loss of blood, was felt to be of major importance. An analysis and the significance of metabolic disturbances, including anemia and hypoproteinemia often appearing after recovery from wound shock were elaborated upon.

Robert Rustigian and **Arthur Cirpriani,** United States Army Sanitary Corps: **Bacteriology of Open Wounds.**—Two hundred fourteen bacteria comprising the complex floras of twenty-seven septic and nine contaminated war wounds were differentiated functionally as (1) toxigenic and/or invasive, (2) proteolytic, and (3) commensals. The first group, the true pathogens, included *Staphylococcus aureus, Streptococcus pyogenes,* and gas gangrene bacilli. The proteolytic bacteria were considered as wound pathogens and included *Clostridium sporogenes, Clostridium putrificus* group, *Clostridium bifermentans,* Proteus, Pseudomonas, *Bacterium melaninogenicum,* and certain anaerobic streptococci. The predominant commensal bacteria were the enteric and undifferentiated streptococci, micrococci, and coliform bacteria.

Howard E. Snyder, Winfield, Kan.: **Blood Replacement in Wound Management.**—Adequate and timely blood replacement was a very important factor in the reduced mortality of battle casualties admitted to hospitals in World War II. Clinical observation, followed and substantiated by laboratory investigation, proved that whole blood loss rather than plasma was the cause of reduced blood volume. The replacement by whole blood was found essential to the successful management of cases in severe shock. It not only reduced the mortality rate but also decreased the morbidity, hastened convalescence, and permitted extensive early reparative surgery. In forward hospitals, banked blood titered for anti-A and anti-B agglutinogens was found most satisfactory.

Champ Lyons, New Orleans, La.: **The Role of Chemotherapy in Wound Management.**—The open wound is vulnerable to two types of bacterial inflammation: (1) invasive infection and (2) wound suppuration. The former is due to hemolytic streptococcus, toxigenic clostridiums, or staphylococcus. The process of suppuration is locally necrotizing and gives rise to nonspecific toxemia. It was reported that proteolytic bacteria, lacking in invasive attributes, are frequently insensitive to available antibacteriocidal drugs. They are designated as "wound pathogens." "True pathogens" are both invasive and proteolytic. Chemotherapy by the systemic route controls only impending or established invasive infection. It was stressed that no method of chemotherapy can substitute for technical and surgical management of wound suppuration.

Francis B. Berry, New York, N. Y.: **Surgical Principles in Wound Management.**—Wound healing and management from the historical standpoint were discussed. The normal processes of healing in the various tissues were elaborated upon, stressing the importance of local and systemic factors. The local factors included devitalized tissue, sequestrums, foreign bodies, blood supply and vascularity, dead spaces, and infection. The systemic factors included age, hydration, protein balance, nutrition, anoxia and anemia, circulation, and vitamins. The role of antiseptics and bacteriostatic agents and wound stimulants were discussed along with the preparation of the wound and the handling of tissues.

Ralph Adams and **Bernard J. Ficarra,** Boston, Mass.: **An Appraisal of Surgery in the Treatment of Bronchiectasis.**—The surgical treatment in a group of fifty consecutive cases of bronchiectasis carried out during the five-year period ended Aug. 31, 1945, was reported. Clinical, pathologic, and psychologic manifestations of the disease, and important principles and details of surgical treatment, were given. Eight patients developed postoperative complications, five empyema, two bronchopulmonary fistulas, and one thrombophlebitis. Forty-two patients were reported cured. The mortality rate was zero.

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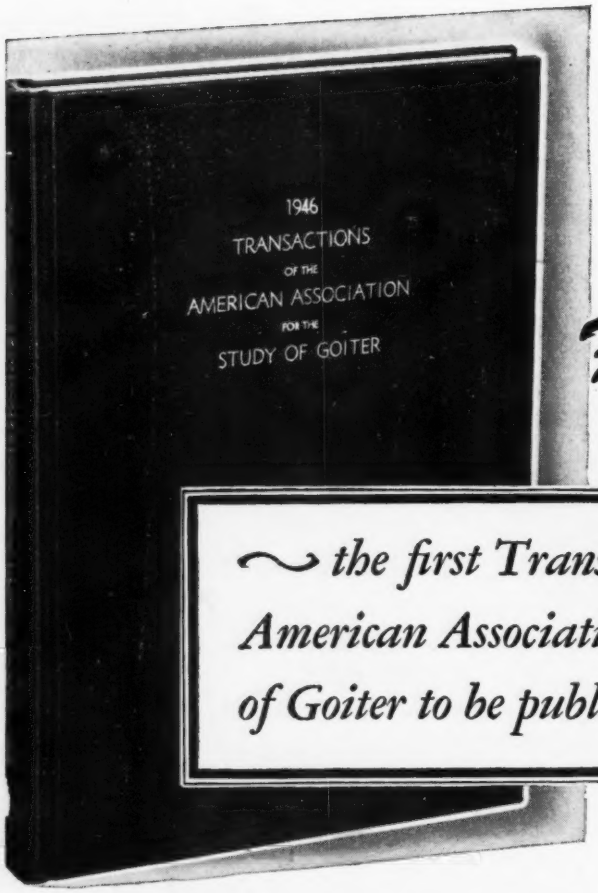

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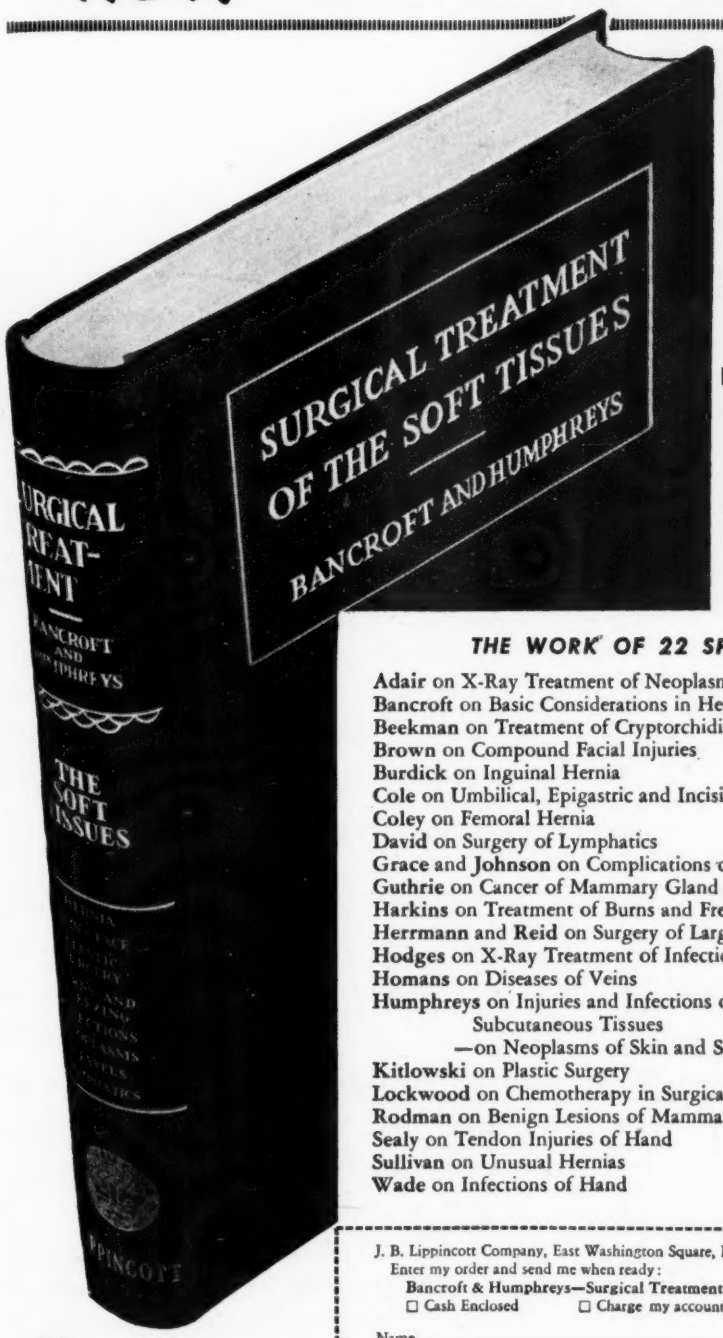

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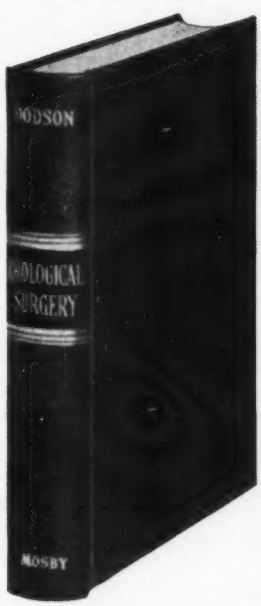

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